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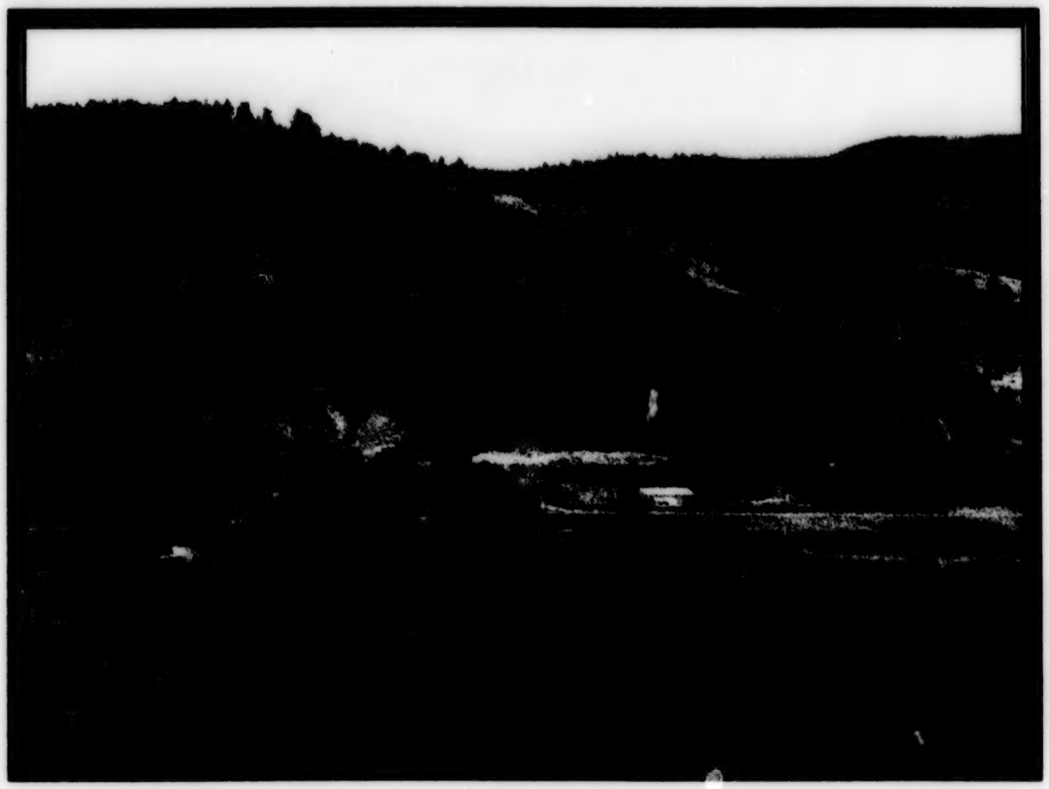
ENVIRONMENTAL ASSESSMENT

NO. EA-130-08-14

Bureau of Land Management
Spokane District Office
Border Resource Area

July 24, 1998



LAMEFOOT MINE

Plan of Operation Modification

WMP-130-89-019B

Interim 3070/North Lamefoot Proposed Modification

98-034678

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

BLM/OR/WA/EA-98/031+1792

I

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Spokane District Office
1103 N. Fancher
Spokane, Washington 99212-1275

IN REPLY REFER TO:
WMP-130-89-019B
3809 (1350

July 30, 1998

LAMEFOOT MINE
NOTICE OF AVAILABILITY OF ENVIRONMENTAL ASSESSMENT AND FINDING OF NO SIGNIFICANT IMPACT

Dear Reader,

The Department of the Interior, Bureau of Land Management (BLM) has completed the review and analysis of continued mine development and interim underground expansions at the Lamefoot Mine in Republic, Washington. The mine has been in production since 1994 and is within about one year of completing mining within the initial ore zones. The expansions will allow continuance of ongoing operations by Echo Bay Minerals Company while a technical analysis is completed for possible future exploration and development. The operations would be consistent with BLM's decision of November 1994, as revised in September 1995, allowing development subject to measures to mitigate potential impacts to ground and surface water quality. Proposed operations would follow the mitigation measures identified in these previous decisions and apply them to the new expansion areas.

Ongoing monitoring has been performed since 1994. Additional geologic, hydrologic and geochemical studies have been performed since 1996 to evaluate changes in mine conditions as operations progressed. BLM has conducted an environmental analysis of these studies and completed an Environmental Assessment to determine the scope of impacts from existing and proposed development, including an alternative for a slightly larger expansion that was a part of the studies. This analysis concludes that mitigated development will not cause unnecessary or undue impacts and will involve impacts similar in intensity and effect to those previously predicted. The analysis determined that the mitigated impacts identified are within the scope of those analyzed and portrayed in the 1994 Lamefoot Mine Final Environmental Impact Statement Supplement.

The BLM is therefore proposing a Finding of No Significant Impact (FONSI) for both the Proposed Action and the larger alternative expansion, and authorization of the alternative larger expansion. Given past and continuing public interest in this project, the Environmental Assessment and FONSI are being provided for public review and comment prior to issuance of a decision.

Copies of the Environmental Assessment and proposed FONSI are available for review at the Republic, Omak, Oroville, Okanogan, Colville and Spokane Public Libraries. Copies will be mailed to parties previously on the distribution list where there is a current address of record. In addition, copies are available on request from the Bureau of Land Management, Spokane District Office, Border Resource Area at 1103 N. Fancher, Spokane, Washington, 99212-1275, or by calling BLM at (509) 536-1200.

There will be a comment period of 15 days. Comments will be accepted until close of business on August 14, 1998.

Rick McCamas

Cliff Ligons
Border Resource Area Manager

II

LAMEFOOT MINE
ENVIRONMENTAL ASSESSMENT
EA-130-0-08-14

FINDING OF NO SIGNIFICANT IMPACT (FONSI)

Based on the analysis of potential environmental impacts contained in the attached environmental assessment, I have determined that the impacts associated from mining expansions (exploration, development and mining activities), as mitigated, are not expected to be significant, and therefore an environmental impact statement is not required. This applies to both mining expansions described in the Proposed Action and in Alternative 2, Enlarged Interim Expansion. Mitigation includes the measures identified in the 11/30/94 Record of Decision as modified by the 9/20/95 Record of Decision and implemented by the 12/12/96 Record of Decision. Additional mitigation that would apply is described under the Recommended Mitigation in the Environmental Assessment.

RATIONALE: Conclusions from the additional analyses that have been conducted since completion of the November 1994 Lamefoot Mine Environmental Impact Statement indicate that the mine water would likely remain in the near-neutral range during filling, and that acid-generating reactions would be controlled by the mitigation measures after the mine partially refills to the elevation of Wolf Camp valley. The mine may refill to higher levels, depending on the degree of outflow through bedrock, but it appears unlikely that the mine may completely refill as analyzed in 1995. Mine waters may exit through the crown pillar through faults, fractures or ungrouted boreholes, preventing complete refilling.

Grouting measures required in the 11/30/94 Record of Decision should be capable of controlling seepage and discharge. Mitigation measures would neutralize acid generation and maintain concentrations of dissolved constituents in mine water at levels somewhat higher than naturally elevated pre-mining conditions. Most dissolved constituents would be retained within the mine pool or within the project area immediately surrounding the mine if all operational mitigation measures are carried out in an effective manner. If discharge does occur, other mitigation measures in the 11/30/94 Record of Decision would be implemented to prevent impacts outside the project area, such as corrective post-closure grouting, and if necessary, installation of a treatment plant and drawdown of mine waters.

The proposed modifications described in the Proposed Action and Alternative 2 and the measures required by the previous RODs described above, as incorporated in the plan of operations, would likely ensure prevention of most possibilities for unnecessary or undue degradation, although there are some uncertainties in predictive capabilities and mine conditions. However, since any uncertainties can be overcome by the mitigation measures, it would be unlikely that the proposed operations would result in unnecessary or undue degradation of resources outside the project area.

______________________________ ________________________
Cliff Ligons Date
Border Resource Area Manager

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1.0 NEED FOR THE PROPOSAL

In 1994, the Final Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion (FEISS) (1) analyzed the mitigation measures and potential impacts from the Lamefoot Mine, an underground gold mine. The FEISS and 11/30/94 Record of Decision (ROD)(2) required additional studies for the full mining which were analyzed in the 9/20/95 Full Mining Proposal Plan of Operations Modification Environmental Assessment (9/20/95 EA) (3).

The purpose of this environmental assessment (EA) in 1998 is to determine whether existing actions and proposed modifications may involve cumulatively significant unmitigated impacts not addressed in the FEISS that require analysis in a new supplemental impact statement. This EA is tiered to the FEISS and 9/20/95 EA. This EA analyzes existing and reasonably foreseeable actions to avoid a "piecemealing" approach to incremental additions and ensure that analysis of reasonably foreseeable impacts is comprehensive.

The Bureau of Land Management (BLM) is required to assess, *"the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."* (40 C.F.R. §1508.7).

The FEISS evaluated underground mining involving inclined ore zones totaling about 1500 ft. long and about 60 to 130 ft. wide, potential production ranging from about 943,000 tons up to about 2,967,900 tons of proven and possible ore, up to about 360,000 tons of waste rock, and using a total of about 1.6 million tons of backfill, including about 164,300 tons of potentially acid-generating (PAG) waste rock. The crown pillar and wall rock were estimated to contain over 1.52 million tons of PAG rock.

The proposed action involves modification of the operations within the existing underground Lamefoot Mine due to changes in the natural conditions (more potentially acid generating waste rock and some zones with greater capacity for water movement) as compared to the original predictions for the authorization. The proposed action also involves an expansion of the underground mining activity in two general areas. At the southern end of the mine, the proposal involves adding up to 7 drift and fill levels for expansion upward and eastward to access an extension of the Zone 2 ore mineralization. At the northern end of the mine, the proposal involves expansion from the current mining limit for most levels by up to 600 ft. northward and mining to deeper levels below the 2200 ft. elevation to follow extensions of ore zones and also access some new deposits.

Excluded from this "Interim" proposal and analysis for this environmental assessment are future exploration and mining zones referred to as Zone 7 and "north" North Lamefoot, but they are mentioned to identify the possible magnitude of reasonable foreseeable cumulative actions.

The need for the current EA originally arose from review of monitoring data that indicated that operations were likely to produce substantially more PAG waste rock than had been analyzed in 1995 and authorized in the 9/20/95 ROD(4). That analysis projected that only about 164,300 tons of PAG waste rock would be produced and used as backfill for the life of the mine. Mitigation measures were designed to augment and maintain a high level of neutralization in the mine to control any acid generation from the waste rock, mine walls and crown pillar. However, about 175,453 tons of PAG waste rock had been placed by late August 1996. This amount had risen to about 265,000 tons by early 1997 and revised projections indicated PAG waste rock could total up to 337,000 tons for the authorized area. This was considered to be a potentially substantive change in conditions that warranted further environmental analysis to verify whether the mitigation would remain effective and whether BLM needed to request a plan modification.

Also in 1996, exploration work by Echo Bay Minerals Company (EBM) began to identify possible ore targets for future mine expansions.

Mining zones for the interim expansions (**Proposed Action, Section 4.1**) range from about 60 to 215+ feet wide. The interim development and mining zones would increase the overall mine lengths variable distances to as much as 1850 ft. long. The longest exploration drift has increased the overall length of the mine workings to about 2300 ft. extending down to about the 2100 ft. elev. msl., and the interim expansion would add another access ramp down to the 2100 ft. elev. msl.

Life of mine production is estimated by EBM to involve up to about 3.1 million tons of ore and up to about 1.25 million tons of waste rock. Future expansions for Zone 7 and "north" North Lamefoot could increase the depth of the mine to the 1880 ft. elev. and extend the overall length of mining zones to 2300 ft. or more. Proposed and future operations could use up to about 2.2 million tons of backfill, with up to about 625,000 tons of cemented backfill.

Underground tonnage projections for PAG rock are difficult because the potential expansion areas haven't been fully explored by drifting and drilling, but obtaining the data requires excavating access. However, even with access, difficulties in identifying tonnages of waste rock persist. In February, 1998, the proposed interim expansion would have added about 37,000 tons of PAG waste rock to existing authorized areas, resulting in a total of about 450,400 tons of PAG waste rock. However, by the end of May, 1998, the existing backfill already totaled about 442,600 tons of PAG waste rock, only 7600 tons less than proposed cumulative tonnage for the interim expansion. The existing backfill plus the interim expansion would probably result in at least 479,400 tons of PAG waste rock and probably more because mining and development within previously authorized areas will be in progress for another year. This suggests that the cumulative PAG tonnage that will be produced from the existing operations may have been underestimated and may be substantially more than EBM's projections.

Although about a year of production remains, it takes time to excavate access to new areas and pre-mining development around ore zones, so it is necessary to start this work soon if production is to be continued a year from now without disruption. Excavation of access is needed in advance into potential new exploration targets to determine the characteristics of ore and waste and the economic feasibility of mining. These potential deeper zones are too far below the surface to economically or accurately obtain most of the information by surface drilling.

The 1997/98 geochemical model evaluated about 1.81 million tons of backfill, including a base case of about 501,000 tons of PAG waste rock. BLM considered the possibility that PAG waste rock might range up to about 590,000 tons for alternatives considered at that time. The geochemical model parameters were originally designed in 1997 to consider past uncertainties in tonnage projections within the authorized mining areas, and to evaluate reasonably foreseeable cumulative impacts for two larger possible expansions. However, the actual PAG tonnages for the smaller interim proposal may approach those used in the model.

The larger potential expansions (referred to as the Full Mining Proposal) included the full drift and fill expansion from the 3070 ft. elevation to the 3200 ft. elevation and the full North Lamefoot expansion that included development and mining to the north of the previously authorized limits (including "north" North Lamefoot north of 27850N and below 2200 ft. elevation), and mining to deeper levels at the new Zone 7 below the 2200 ft. elevation.

Although the geochemical model parameters can address the interim proposal and some alternatives, the waste rock tonnage projections for future expansions need to be refined to determine their adequacy because they may be substantially low. Given the discrepancies in tonnages, better projected PAG waste rock estimates for the deposits referred to as Zone 7 and "north" North Lamefoot need to be developed. The "north" North Lamefoot area also involves potentially greater water flows and the hydrological model for that area is still in preparation. Completion of that hydrological study and report is expected later in August, 1998, so it will need to be evaluated in a later environmental assessment. Also, EBM hasn't determined if Zone 7 and "north" North Lamefoot can be economically mined and has not requested this expansion yet.

Implementation of mitigation was another issue for this environmental review. For instance, the 9/20/95 ROD required placement of the majority (50% or more) of the PAG rock in cemented rock backfill to control oxidation of acid-producing sulfide minerals and add more neutralizing material directly in contact with those minerals. In March, 1997, only about 41% of the PAG waste rock had been placed in cemented fill. EBM was required to correct the deficiency(7) and prepare the 1997/98 technical studies. The proportion of PAG rock has since been raised to about 51% of cemented backfill as of May, 1998, with about 226,900 tons PAG waste rock out of about 453,600 tons cemented backfill. Backfill currently includes a total of about 442,600 tons of PAG waste rock, the remaining year of authorized mining would add additional PAG waste rock, and the "interim" expansion proposal would add at least 37,000 tons of PAG waste rock. The amount of cemented backfill would increase proportionately. These tonnages are within the magnitude of the parameters used in the 1997/98 geochemical model to analyze potential impacts.

The status of grouting of boreholes and fractures was also examined. Grouting was a measure relied on in the FEISS as a means of slowing diffuse outflow of mine water and seepage into surface water and shallow groundwater in the Wolf Camp drainage and preventing direct discharge into the drainage through boreholes. Such seepage from ungrouted areas could involve greater outflows or more rapid migration of water with less attenuation.

2.0 BACKGROUND INFORMATION

The Lamefoot Mine is located in north central Ferry County, Washington about seven miles northeast of the town of Republic (**FEISS Figures 1-1 and 1-2**). EBM is one of the major employers in Ferry County. The mine is the primary source of ore for the continued operation of the Key Mill, a regional mill facility for the EBM Kettle River Operations, with supplemental ore supplied by the K-2 Mine. The mine facilities are located adjacent to State Highway 21 within a few thousand feet of the eastern shore of Curlew Lake, Washington. Resorts, private residences and domestic water supplies (community and private wells) are located along the eastern lake shore. Curlew Lake State Park is also located between the mine and the eastern lake shore and it receives numerous visitors annually (78-97,000+/year from 1988-1992).

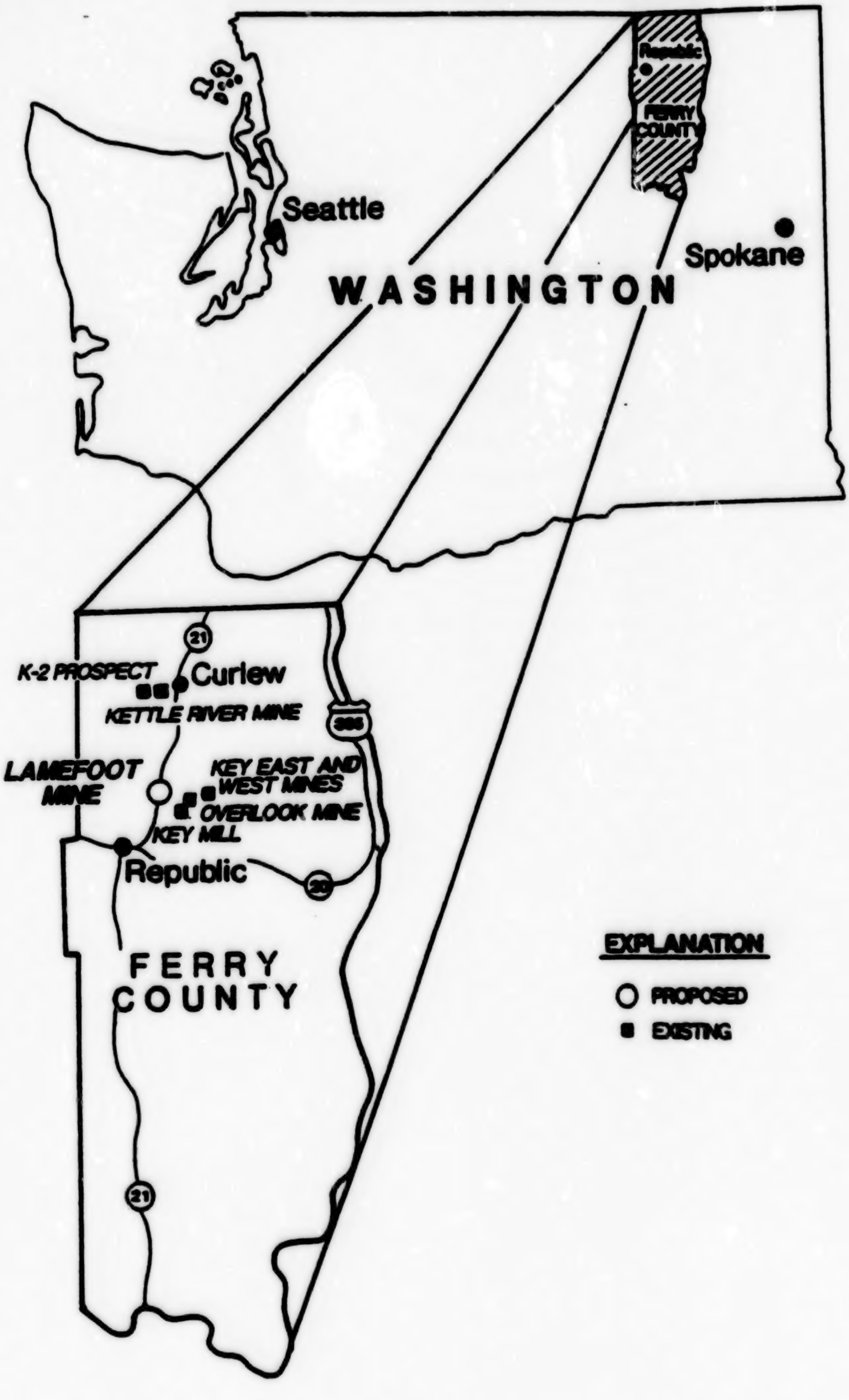
Ore within previously approved mining limits is expected to be depleted in about one year. The current interim proposal is primarily limited to development workings with some mining. The technical studies were initially designed to address a larger mining proposal. However, given the existing sequence of mining and the time required to excavate development workings prior to mining, it became necessary to start development work in order to be able to incorporate the new expansion areas into previous production schedules.

The interim proposal was submitted to reduce the environmental analysis time and allow continued activity for several months while one additional hydrological study is completed for the potential future "north" North Lamefoot expansion area and for deeper mining below the interim area. The interim proposal also extends into this same zone which has potential for greater water movement, but does not extend to the area which had the highest flows. There has been extensive discussion between BLM and EBM on the interim and "full" proposals. The data provided for the development and potential ore mining zones within the interim area were sufficient to address both development and mining in selected areas, excluding "north" North Lamefoot and the new Zone 7 beneath the interim proposal.

Note that EBM's consultants consider BLM's analysis scenario to be extreme and assert that the study parameters and analyses required by BLM are too conservative. The consultants have presented their **"expected"** scenarios showing that impacts will be substantially less than indicated by the scenarios that BLM required to be modeled for the **"conservative"** scenarios.

BLM acknowledges that the "conservative" modeled scenario is conservative, but does not agree that it is extreme. For the conservative scenario, the BLM required use of all actual geochemical and water data and test results, current summaries of backfill, more accurate predictions of waste rock quantities, and assumptions for post-closure conditions that would realistically be expected occur. The conditions identified by BLM are conservative in the timing and degree of conditions, in that it is less likely that all of these conditions would occur simultaneously to the degree indicated but such conditions are possible. The degree of impacts will depend on when or even whether all identified conditions actually develop over the long predicted lag times, and the actual degree of effectiveness of mitigation measures in preventing or controlling impacts.

Although more extreme conditions are possible and were analyzed as part of sensitivity analyses, BLM considers such conditions unlikely to occur, except for the likelihood that PAG waste rock tonnages may exceed the base case projections. Given the present information, the actual case would likely fall somewhere between the consultants "expected" scenario and BLM's "conservative" scenario. As such, BLM's scenario for modeling represents a conservative analysis for prediction of reasonably foreseeable impacts, particularly given that the rationale for the 11/30/94 ROD, Section VI, concluded that "even the remotest possibility of acid mine drainage affecting Curlew Lake and domestic wells outside the project area is unacceptable and would be regarded as unnecessary or undue degradation to the environment".



CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

DRAWN
CHECKED J.C.
REVIEWED L.E.C.

TITLE
GENERAL LOCATION MAP

SOURCE: ECHO BAY, 1993a

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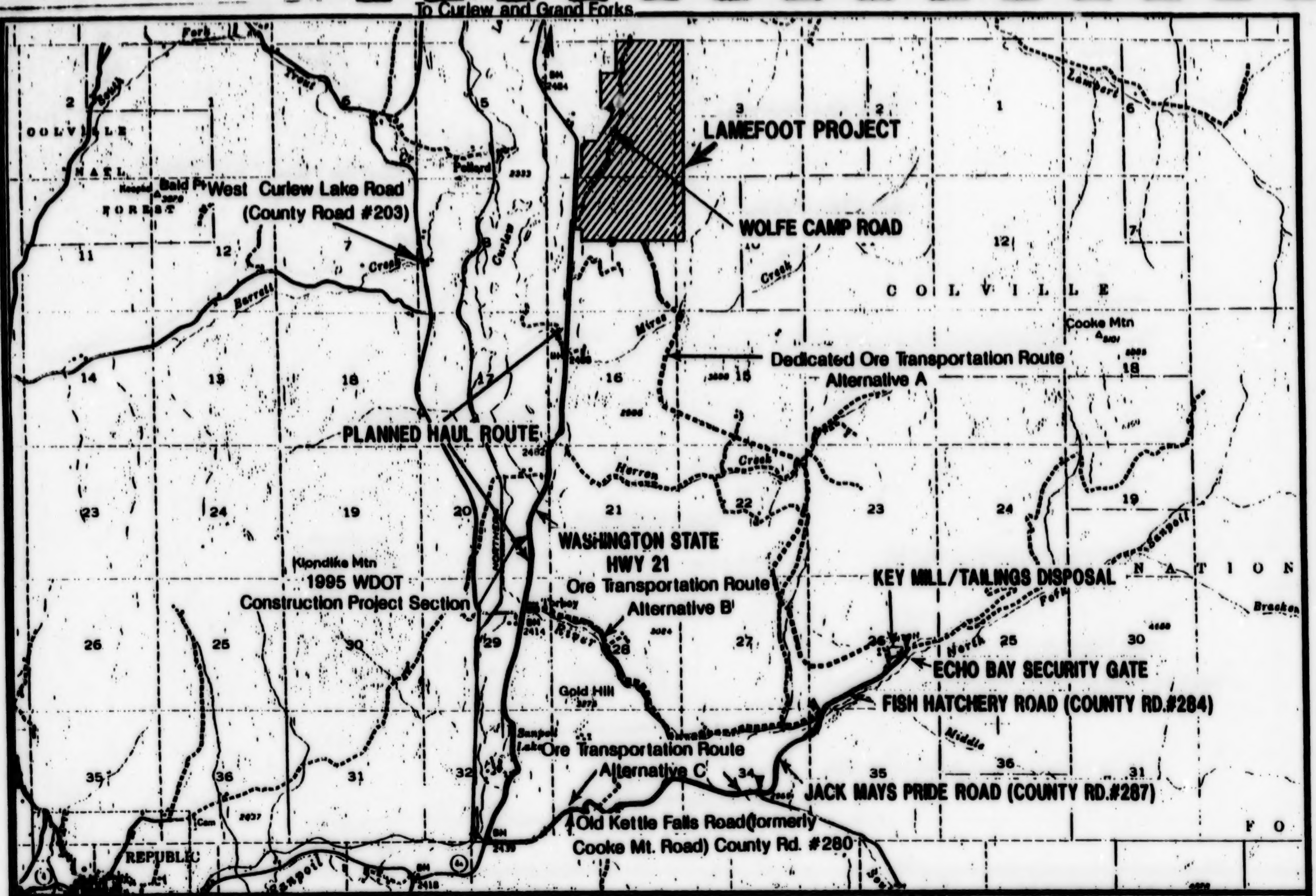

CLIENT/PROJECT
ECHO BAY MINERALS Co.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

ECHO BAY MINERALS, INC.

TITLE
LAMEFOOT PROJECT
SITE ACCESS AND REGIONAL
TOPOGRAPHY

Source: Echo Bay 1993a

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3.0 INTRODUCTION

As part of the EISS process, BLM reviewed the analysis presented by EBM and Woodward-Clyde Consultants. In analyzing the potential environmental impacts associated with EBM's proposal for mining at the Lamefoot Mine (the 1994 Lamefoot FEISS proposed action) and the analysis by Woodward-Clyde Consultants, the BLM determined that the anticipated impacts to the environment would generally be low.

However, as a result of public comment on the draft EISS and additional analysis of information existing at that time, the BLM determined that more data was needed to verify the predicted low probability of degradation of groundwater outside the project area. The FEISS considered that potential generation and drainage of acid mine water into underground excavations extending below the projected post-closure water table of 2750 feet msl elevation might have a higher potential for water quality degradation.

BLM then developed the Limited Mining Alternative based on questions raised about some of the conclusions in the FEISS and identified a number of issues that required further study. BLM determined in November 1994, as a result of the additional analysis, that it did not have sufficient information to authorize full scale mining at the Lamefoot site. Instead, the BLM authorized the Selected Alternative for mining only those portions of the ore bodies located above the projected post-closure water table of 2750 feet msl, and required EBM to conduct additional studies relative to geology, geochemistry, groundwater, surface water, acid generation characterization and similar matters to better evaluate the potential for environmental impacts. The Record of Decision (ROD) of 11/30/94 noted that, if the additional data gained from these studies corroborated the predicted low impacts identified in the FEISS for full mining, additional plan modifications would be considered under the Selected Alternative focusing toward full development.

In the fall of 1994, EBM initiated a range of specialized studies primarily related to groundwater and geochemistry. Additional water wells were drilled, field tested and monitored to evaluate the background water quality and the nature of the groundwater system, particularly the fracture system around the mine. This data was subjected to intensive analysis, including use of computer models to assist in developing predictions of groundwater flow, mine filling rate, water quality in the refilled mine, and natural removal of reaction products by flow through bedrock and glacial deposits.

Subsequently in 1995, EBM requested the BLM to authorize additional mining below the 2750 foot msl elevation approved in the 11/30/94 ROD and allow ore extraction down to the base of the ore deposit at 2200 foot msl elevation based on the results of extensive studies conducted to analyze the potential for degradation of surface and groundwater. EBM also asked BLM to develop backfill criteria, and requested authorization of an alternate backfill plan involving blending acid-neutralizing and non-acid-generating material in the backfill, instead of the blending and layering approach required by the 11/30/94 ROD. The original backfill source contained PAG rock and required amendment to meet the backfill criteria in the 11/30/94 ROD. Use of an alternate backfill source with less sulfide content was proposed to enhance overall neutralization capacity and minimize the potential for backfill to contribute to acid generation. Backfill was projected to contain about 9% PAG waste rock.

The additional information from the 1995 studies indicated that it was possible for the revised mining and backfill plan to achieve the predicted low impacts of full mining. This information is summarized in technical documents collectively referred to as the "2750 Report", and related supporting documents. Additional environmental studies have been completed by many technical specialists, primarily related to potential impacts to water resources, and this work has continued through 1998. Because many of the studies are lengthy and technical in nature (e.g., Section 8.0), the results are summarized in this EA. **Appendix A** provides a comparison of the conclusions from the 1994, 1995 and 1997/98 studies and environmental analyses.

The BLM conducted a detailed technical review of the studies presented in the 2750 Report and the proposed modifications. BLM also had the Bureau of Mines(46) conduct an independent review of the hydrology and geochemical studies, the proposed change in backfilling source and method, and the overall impact evaluation. Based on this work, BLM analyzed and documented the impacts in the 9/20/95 EA.

Although the technical reviews did not agree with all the findings of the 2750 Report, suitable measures to mitigate potential impacts were identified. BLM concluded that it would be possible to mitigate the major environmental impacts associated with the full mine development (as defined in 1994), and that mitigated development would not be expected to cause unnecessary or undue degradation. Based on the 1995 information, BLM authorized an alternate backfill source and a different approach to selective handling and encapsulation that allowed more flexibility in scheduling the handling of the backfill materials.

The updated mitigation was documented in the 9/20/95 ROD. Key backfill criteria include placement of 50% or more of PAG waste into cemented fill, blending PAG and neutralizing rock types to emulate natural non-acid-generating characteristics, and ensuring that every 5,000 ton sample lot mixture has a net neutralization potential greater than 20 tons calcium carbonate per thousand tons (NNP >20 TCaCO$_3$/KT) and a ratio of neutralization potential to acid-generating potential of greater than three to one (NP:AGP >3:1) before the addition of cement.

The 11/30/94 ROD had required EBM to modify the original Plan of Operations and incorporate the Selected Alternate and associated conditions of approval into the Plan of Operations. The ROD noted that, "to the extent that there are any discrepancies between the Plan of Operations and this Record of Decision, EBM shall revise the Plan of Operations to conform to the Record of Decision." Similarly, the 9/20/95 ROD required EBM to modify the Plan of Operations to comply with additional conditions of approval, and to prepare a single document that adhered to the measures of these ROD's.

In 1996, EBM revised the Plan of Operations to incorporate the measures required in the Record of Decisions of 11/30/94 and 9/20/95. BLM's review of the plan of operations also evaluated an EBM change in the backfill testing approach from that analyzed in the 9/20/95 Environmental Assessment (EA). The approach involved placing the backfill into the mine before receipt of laboratory test results instead of afterwards. The 12/12/96 ROD approved the Plan of Operations subject to the measures required in the 11/30/94 and 9/20/95 RODs.

However, by late 1996, monitoring indicated that the backfilling had already placed as much PAG waste rock as had been projected for the life of the mine. The 9/20/95 EA had evaluated the impacts from the overall mine and use of about 1,860,000 tons of backfill, including about 611,000 tons of waste rock of which about 164,300 tons would be PAG waste rock (9% of total backfill). By early 1997, about 265,000 tons of PAG waste rock had been used in backfill. Revised life of the mine projections estimated that there would be up to 337,000 tons PAG waste rock produced within the previously authorized mining limits.

During this time period, EBM also began considering proposed expansions in two areas. These involved upward expansions at the southeastern end of the mine (3070+ expansion), and expansions at the northern end of the mine northward and deeper beyond authorized boundaries (i.e, North Lamefoot). In addition to increasing the size of the crown pillar area and potentially exposing more PAG rock to oxidation, estimates indicated that the expansion could increase the amount of PAG waste rock in the backfill to a total of over 500,000 tons.

Total backfill to date involves about 1.22 million tons, of which about 442,600 tons is PAG rock. About 51% of the PAG rock (226,900 tons) has been encapsulated in cemented backfill. The blending criteria requires achieving NNP >20

$TCaCO_3/KT$ and NP:AGP >3:1 before the addition of cement for every 5,000 ton sample lot. The criteria also requires that over 50% of the PAG waste rock be placed in cemented backfill. The FEISS evaluated use of about 345,000 tons of cemented backfill. The 9/20/95 EA looked at use of about 250,000 tons of cemented backfill. As of the end of May, 1998, cemented backfill involved about 453,600 tons, or about 37% of total backfill.

Life of mine projections may range from about 450,000 to 594,000 tons of PAG waste rock, depending on the expansions considered. The projections change continually as mining encounters different proportions of rock types and should only be considered to indicate the general order of magnitude of PAG tonnage anticipated (**Table 1**).

Since these tonnages involved potentially substantive differences from the 9/20/95 EA and FEISS, BLM required EBM to prepare technical studies analyzing the reasonably foreseeable impacts of the increased PAG waste rock from the authorized mine area, and the additional PAG waste rock that would be excavated and backfilled for the proposed expansion areas.

The ROD criteria focus on PAG tonnages as a means to implement the mitigation measures to prevent future degradation, to monitor the effectiveness of the implementation, and to track and quantify the potential for impacts that may result in the future after a long lag time. However, it should be understood that the environmental analysis issue is not the specific tonnages but rather the potential for and magnitude of impacts that may result. The mitigation measures were designed to handle the potential for large variations in tonnages and conditions. Since the tonnage projections change continually, the focus of the technical studies was to define the effects of current and proposed expansions in terms of the likely impacts within a general mining area. Broader estimates for conditions were used to analyze the effectiveness of the mitigation measures for the projected tonnages and mining areas, and to examine the potential upper limits for parameters that might involve significant impacts (e.g., what quantity of PAG waste rock might exceed the capacity of the mitigation measures to control acid generation from the waste rock, wall rock and crown pillar?).

BLM required EBM to update the technical data and analysis, re-examine the issues in the "2750 Report" and ensure that the analysis provides realistic conservative predictions using all the past data and test results, updated information from monitoring data, and revised projections of backfill material quantities. Models were required to based on conservative assumptions about potential reactions, post-closure conditions identified by the BLM, and input parameters that were to be reviewed by BLM for concurrence prior to running the models. The geochemical model was revised to include PAG and NAG (non-acid-generating) tonnages of actual backfill and revised estimates through life of mine. The hydrology model was calibrated against actual groundwater data and measured impacts to date.

Sensitivity analyses were run on the models to verify that input parameters and predicted scenarios provided reasonable results, and that the models addressed all factors that might substantively influence the predicted outcomes. Sensitivity analyses tested upper and lower water quality limits that were substantially beyond those expected to occur at the mine, including larger drawdown areas that might expose surrounding rock to oxidation. Since underestimates of PAG tonnage persist, sensitivity analyses also addressed the effectiveness of the backfill mitigation measures and the potential water quality effects if substantial additional PAG waste rock is produced and incorporated into the backfill.

BLM had an independent evaluation([16, 17, 18]) and modeling performed to analyze the potential for subsidence and movement of water through the crown pillar (i.e., the rock between the ground surface and the mine workings). That analysis found that there would likely be a sufficient net increase in the size of fractures to potentially create a post-closure outflow pathway that might allow all of the inflow water to move out

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TABLE 1. LAMEFOOT MINE Projected Tonnages of Potentially Acid Generating Rock (PAG), Revised Estimates for Original Authorizations, Interim Operations, and Proposed Expansions	PAG tons analyzed and authorized by ROD/EA	PAG tons exceeding level approved under 1995 EA	Additional PAG tons in proposed or future modifications	Cumulative Total PAG in excess of 1995 EA from existing and proposed or future modifications	Cumulative Total PAG Tons Authorized/Proposed/Future Expansions	Actual Total PAG tons placed in mine backfill
1994 FEISS	144,000	0			144,000	
1995 EA	164,300	0			164,300	
Actual PAG tons 4/97*	164,300	100,700				265,000
Actual PAG tons 12/97						384,885
Actual PAG tons 5/98						442,595
Revised Life of Mine estimate within 1995/96 plar	164,300	172,700			337,000	
3145 ramp, authorized 6/20/97	**	41,200		213,900	378,200	
2225N drift, authorized 6/27/97	**	16,300		230,200	394,500	
Zone 4 N extension, authorized 4/97	**	19,100		249,300	413,600	442,595
2/98 "Interim" modification estimated PAG tonnages (may include some tonnage from "North" North Lamefoot future expansion***			36,776	286,076	450,376	
"North" North Lamefoot, possible future mine expansion			115,000	401,076	565,376	
Total Proposed/Possible PAG ton increases over 1995 EA amount	164,300	249,300	151,776		565,376	
PAG tons from existing authorized areas exceeding 1995 EA analysis plus proposed 2/98 interim modification***	164,300	249,300	36,776	286,076	450,376	
Actual PAG tons placed in mine to date plus proposed 2/98 interim modification (existing operations have 1 year remaining)	164,300	278,295	36,776	315,071	479,371	estimate >479,371
PAG tons evaluated in Geochemical Model****					501,800	442,595
Proposed Life of Mine PAG tons based on actual PAG tons to date, past expansion estimates for 2/98 expansion proposal, future "north" North Lamefoot.	164,300	278,295	115,000	393,295	557,595	
Current Life of Mine maximum PAG estimate, using actual PAG tons to 5/98,+3070 Expansion tons; assumes 2/98 Expansion tons add to and Full North Lamefoot tonnage estimates*****	164,300	278,295	151,776	430,071	594,371	

* Notice of noncompliance, 3/97, required new tonnage estimates and revising and updating models from 1995 study.

** Interim authorizations conditioned on obtaining the additional information needed for the technical studies and completion of the environmental analysis.

*** 2/98 proposal for an interim authorization includes analysis of cumulative impacts of PAG tonnages.

**** Sensitivity analyses of mitigation measures included range of 1 and 2 million additional tons PAG rock

***** This scenario shows about 7% more tons than the revised estimates and using the 2/98 and North Lamefoot expansion estimates may double-count some or all of 36,776 tons. However, the revised estimates to date have underestimated actual PAG waste rock backfill by at least 7%. Mining has not been completed in authorized zones so more PAG tons are possible through the crown pillar if some of the fractures are connected to the surface/near-surface.

The hydrology analysis evaluated the current information on surface and groundwater quality and flow and identified the existing impacts of mining on drawdown of groundwater levels. This information was used to calibrate the hydrology model. The subsidence model was also used to develop parameters for the hydrology model. The hydrology model was the used to evaluate potential effects on refilling of the mine, the amount of perpetual drawdown that might result and the pathway movement of water out of the mine project area. The hydrology model identifies that drawdown might extend down to a valley level if outflow points exist or develop. The geochemistry model predicts post-closure water quality for the mitigated backfill based on the potential reactions, the quantities and mixture of rock types projected for use as backfill, the types of wall rock exposed, and the effects of perpetual groundwater drawdown to valley level allowing perpetual exposure and oxidation of sulfides in the crown pillar and upper backfill zones.

Figure 1 shows the current mine configuration.

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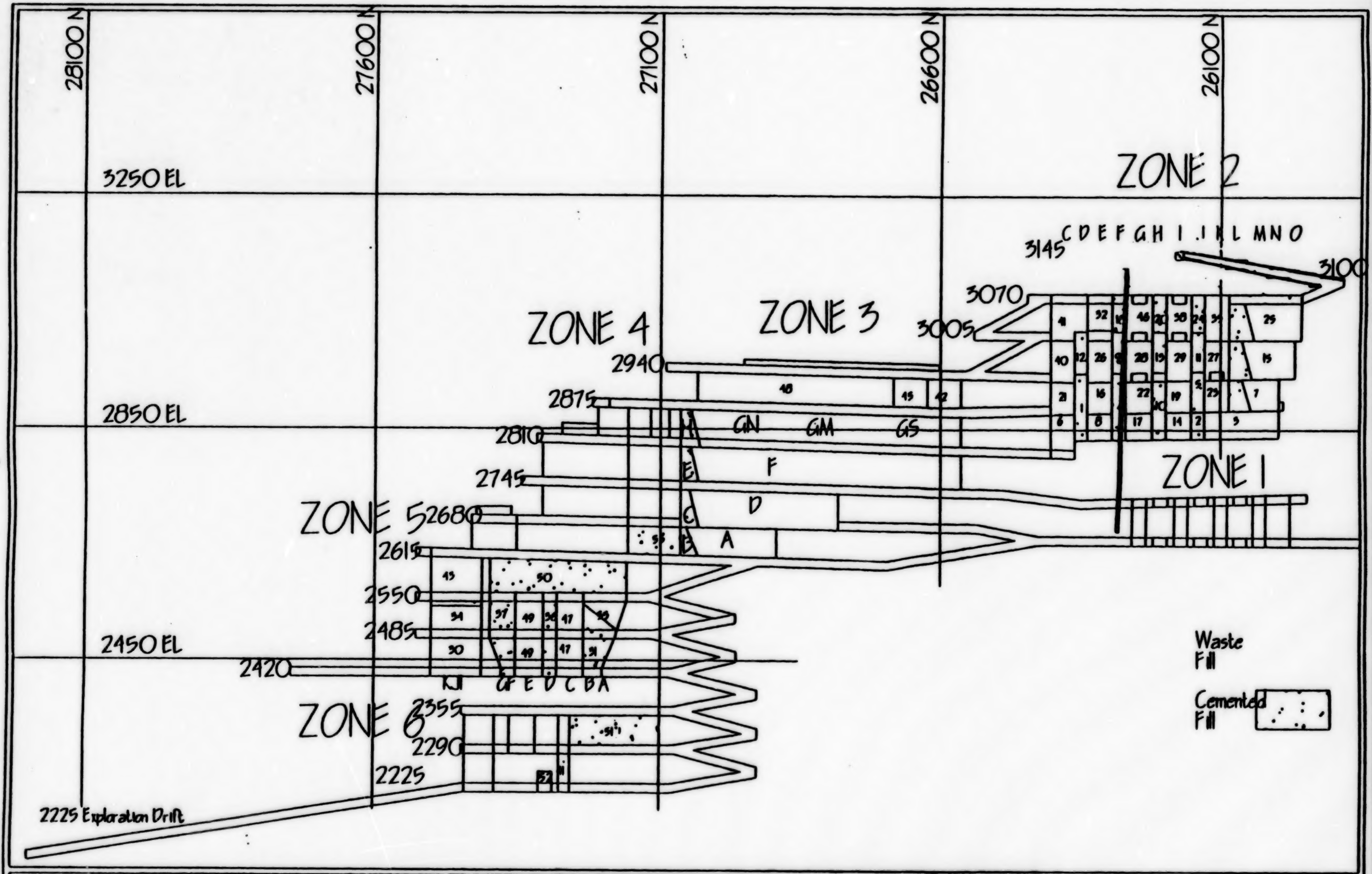

LAMEFOOT MINE - **Figure I. CURRENT MINE CONFIGURATION.** **Illustrates existing mine workings and authorized operating areas. Longitudinal section.**

4.0 PROPOSED ACTION AND ALTERNATIVES

4.1 PROPOSED ACTION

The proposed action would apply all the existing mitigation measures to activities in the expansion areas. The EBM interim expansion proposes a limited expansion involving the lower two lifts of the 3070+ area up to about the 3100 ft. elevation, northward extensions of mining in Zone 4E, northward development of primary drifts in Zone 6E, development of a ramp down to 2100 ft. elevation for access to a new Zone 7. See Figures 2, 3, and 4 for an illustration of the proposal and Appendix B for a more detailed description. Descriptions of the mining methods are presented in the FEISS (Section 2.3.3).

At the Lamefoot Mine project, gold ore is extracted by underground mining methods from the 3070 ft. elevation down to an elevation of 2200 feet msl, and development of the northwest-trending 2225N exploration decline has extended down to an elevation of about 2096 ft at the 28300N coordinate. The proposed action involves expanding the mining and development of selected areas, using the same mitigation measures and criteria required for existing operations under the 11/30/94 and 9/20/95 RODs. As noted in the FEISS, up to about a quarter of the mining project is on public lands (underground mine access, mine stopes, exploration access, drill sites and monitor wells), while the major sources of disturbance are on private lands (mine openings, mine stopes, waste dump, mine buildings and facilities).

The mining method entails drilling blast holes between existing mining levels within the ore body, and blasting rock so that it may be accessed from lower levels. The ore is loaded into underground trucks for transport to the surface. Highway trucks haul the ore by state and county roads to the existing Key Mill processing facility. The ore is processed by conventional carbon-in-leach method. As noted in the FEISS, the processed tailings are stored at an existing zero discharge impoundment (Key Mill and tailings facility) located on private land which, under authorization from the State, was scheduled and permitted for enlargement from 1993 through 1995 to accommodate the tailings from the Lamefoot Mine ore. This facility would continue to be used for any additional ore that is produced by the proposed underground expansion. Process tailings are treated in a cyanide destruction circuit before discharge to the tailings pond and subsequent milling circuit.

At the Lamefoot Mine, ore and some waste rock from underground operations is deposited on limestone pads as a safeguard to mitigate any potential acid rock drainage that might develop from weathering processes. However, most waste rock is mined from one area and hauled directly to another underground area for use as backfill without ever being taken to the surface.

Mined-out areas within the Lamefoot underground workings are backfilled with rock to minimize subsidence and control potential acid rock drainage. Backfill is blended and placed according to criteria from the 11/30/94 and 9/20/95 RODs that are designed to control acid generation from the waste rock, wall rock and crown pillar. Under the proposed action, backfill rock will continue to be obtained from the waste rock and Corl gravel pit backfill sources. All of the waste rock in the surface stockpiles and all waste rock produced during mining will be placed as backfill in underground stopes before or upon completion of mining. Greater than 50% of the potentially acid-generating waste rock will be placed in the cemented rock pillars. Most of the backfill is neutralizing rock that will be supplied by the Corl gravel pit and non-acid-generating (NAG) waste rock sources. Backfill rock quality will be tested as part of an ongoing characterization and blending program to ensure that the mixture meets ROD criteria.

There will be an extensive program during operations for water handling, control and monitoring (11/30/94 ROD, Section IV.E, as modified by the 9/20/95 ROD). Underground seeps are required to be grouted with special methods to control inflow during operations and outflow post-closure as analyzed in the FEISS (e.g., Section 2.4.5, 4.1, 4.2, 4.3, 4.16, Appendix

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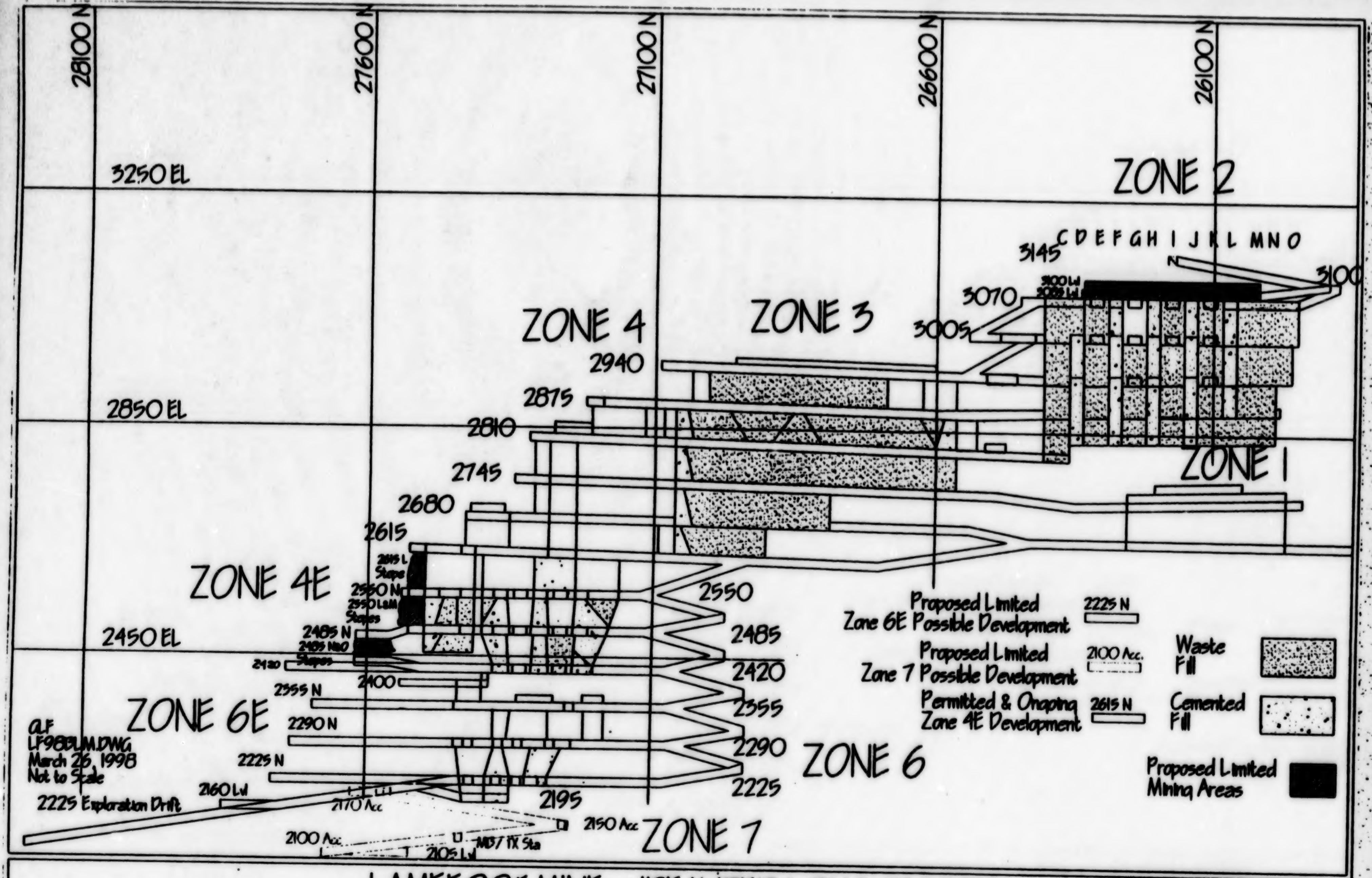

LAMEFOOT MINE - IDEALIZED LONG SECTION

Figure 2. PROPOSED ACTION. Illustrates proposed mine workings for interim expansion. Zone 2 (3070 + w/2 levels), Zone 4E Mining Expansion, Zone 6E Development, Zone 7 access to 2100 ft..

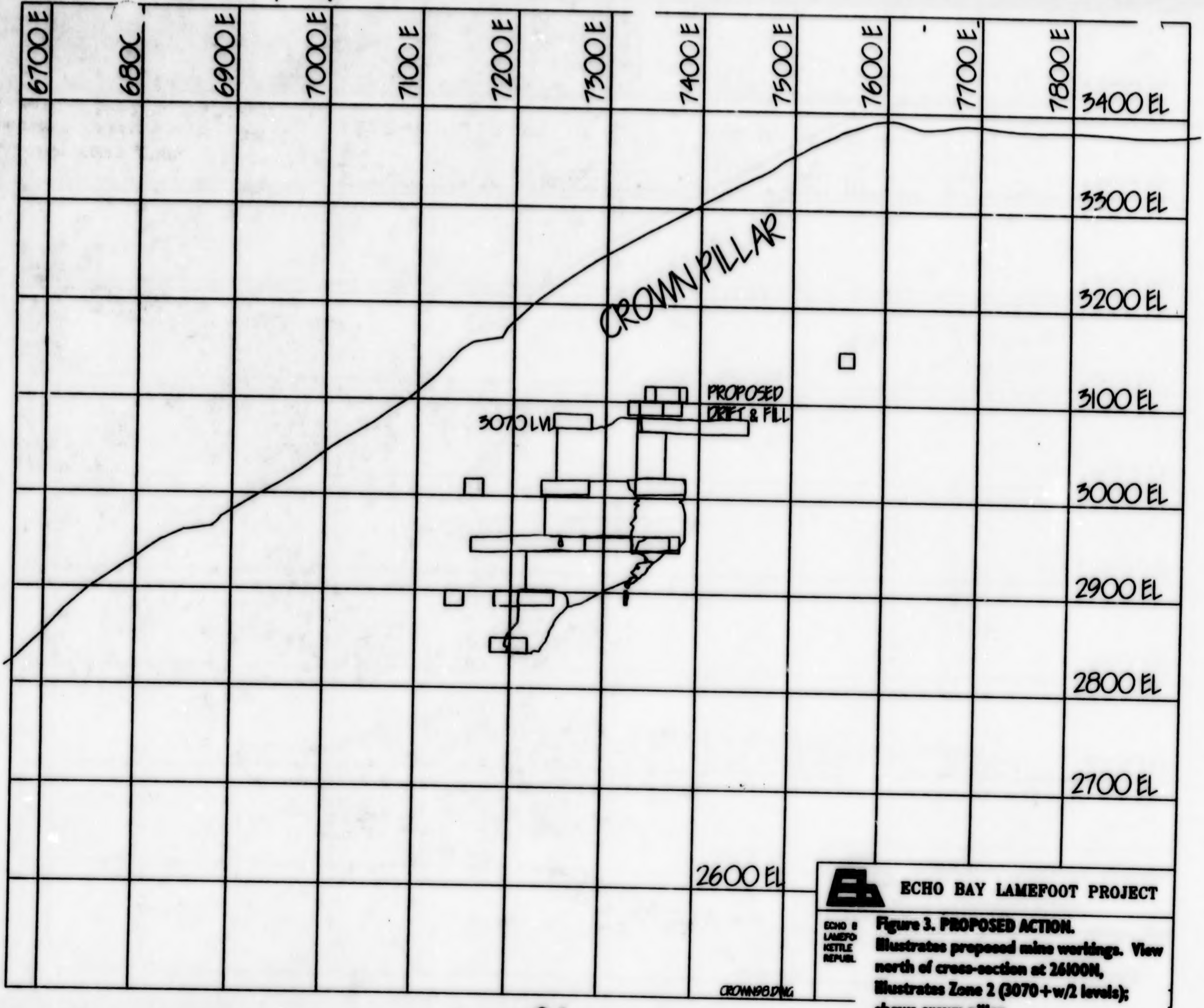

Figure 3. PROPOSED ACTION. Illustrates proposed mine workings. View north of cross-section at 26100N, Illustrates Zone 2 (3070+w/2 levels); shows crown pillar.

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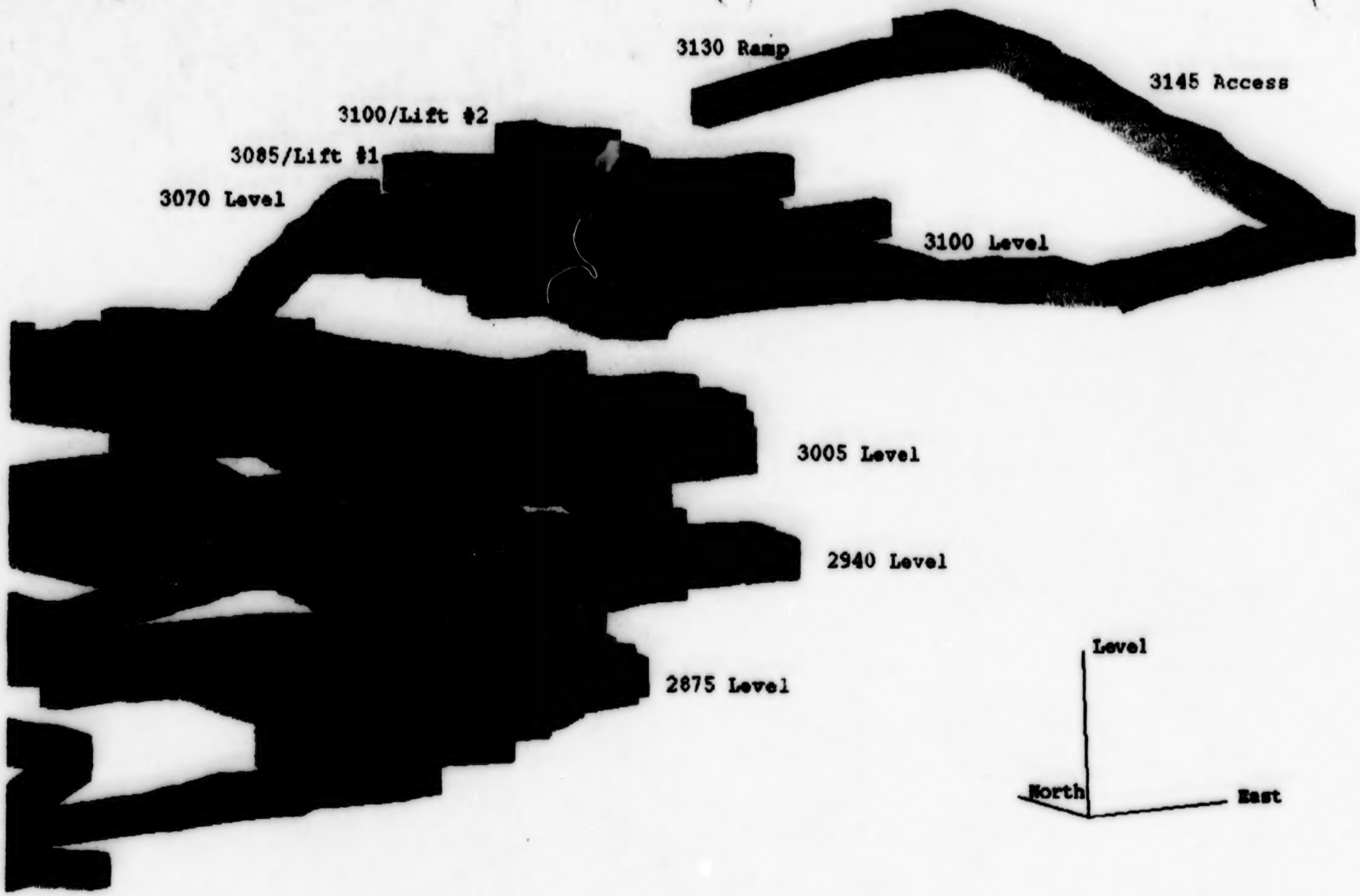

Figure 4. PROPOSED ACTION. Illustrates proposed mine workings. 3-D oblique view of Zone 2 (3070+w/2 levels).

ECHO BAY MINERALS - LAMEFOOT MINE

Intermediary Cut & Fill Production Proposal

B-1, Sect. 4.2, Appendix 6.0, and elsewhere).

Source control has been used to minimize nitrate levels in water. A water monitoring network tracks water quality inside and outside the mine to prevent offsite impacts, and at the end of mining, additional monitoring stations will be installed inside the mine to detect any potential acid-generation. A plant for treatment of discharge water would be constructed during operations or after mine closure if needed.

Exploration drilling will continue from the surface and underground in an attempt to define more ore reserves. Exploration drill holes are required to be plugged and surface disturbance will be minimized as much as possible. Monitor wells will also be sealed when they cease to be used, although the wells may continue to be in use for up to 30 years or more after mine closure and refilling of the mine with groundwater.

Reclamation and monitoring will take place as analyzed in the 1994 FEISS and the 9/20/95 EA and authorized in the 11/30/94 and 9/20/95 RODs. Upon closure, all mine workings will be sealed with bulkheads, internal monitor wells will be installed inside the mine workings, and the upper access road will be converted to a temporary (30 year) surface water diversion above the mine. Following mine closure, the surface and groundwater would be monitored for up to 30 years to verify the predicted effectiveness of measures to prevent and control acid-generation and migration, and monitoring would continue longer if necessary. The monitoring system involves an extensive network of internal and external monitor wells, private wells, and surface water sampling points. If the monitoring system detects water quality degradation that may extend offsite, the monitoring plan would trigger further evaluation and corrective action, including installation and operation of a water treatment facility, if necessary. Ongoing reviews would be conducted to evaluate the effectiveness of the monitoring system and interpretive program.

Following mine closure, the long term objective for managing the public land will be to return it to wildlife habitat after mine closure.

This EA analyzes the following proposed modifications to the previously authorized mining operations as the Proposed Action:

PAG Waste Rock Tonnage

-Increase in tonnage to about 450,000 to 500,000 tons PAG waste rock for operations within the existing mining limits and the proposed interim expansion areas.

Mining Depth

- Removal of ore above the 3070 ft. elevation in upper Zone 2 in two lifts of drift and fill mining, between coordinates 7200E and 7600E; 25850N and 26400N; between elevations of 3085 to 3115 feet, as shown in **Figures 2, 3, and 4**.

- Mining in Zone 4 extension (Zone 4E); primary development only in Zone 6 extension (Zone 6E) between 6500E and 7000E; 27500N and 27850N; between elevations of 2160 to 2650 feet, as shown in **Figure 3**.

- Approximately 1500 feet of ramp construction in Zone 7, between 6400E and 7000E; 27100N and 28000N; between elevations of 2100 feet and 2225 feet, as shown in **Figure 3**.

4.2 ALTERNATIVE NO. 1 - NO ACTION

The No Action Alternative evaluates the possibility that the mining phase might involve unnecessary or undue degradation that could not be allowed. Note that under the law and regulations, mining activities are not discretionary actions under NEPA. Acceptable impacts include the reasonable and necessary degradation associated with the necessary disturbance required for the extraction of minerals within authorized areas.

Under this alternative, EBM would not receive approval for expansion of the Lamefoot Mine if the proposed modifications were determined to involve unnecessary or undue degradation. EBM would be required to carry out reclamation and closure at the end of authorized mining according to the measures in the 11/30/94 and 9/20/95 RODs and approved mining Plan of Operations. If necessary, additional mitigation might be required to correct unnecessary or undue degradation from existing operations. After reclamation, residual conditions would exist as described in the FEISS as modified for the Corl pit in the 9/20/95 EA.

Under the No Action Alternative, the opportunity to develop further mineral resources would be foregone on the public lands. The lack of access would also prevent development of mineral resources on adjoining private lands.

4.3 ALTERNATIVE NO. 2 - ENLARGED INTERIM EXPANSION

This alternative involves the full 3070+ mining, development and mining within the proposed limited expansion area, and exploration of future areas. The full proposal for the 3070+ expansion involves drift and fill mining of seven headings up to the 3200 ft. elevation (**Figures 5, 6, 7**). Alternative No. 2 is essentially the same as the Proposed Action with larger amounts of waste rock and a slightly increased and temporary expansion of drawdown areas. This alternative was developed to avoid numerous repetitive proposals for small incremental expansions as occurred in 1997. Instead, the alternative is designed to provide a comprehensive evaluation of the largest individual expansion that would essentially result in essentially the same impacts as the Proposed Action with adequate mitigation, while providing the exploration access and time needed to obtain the information to evaluate the larger future expansions that are likely to be proposed later for exploration and mining in Zone 7 and "north" North Lamefoot.

PAG Waste Rock Tonnage

-Increase allowable PAG backfill tonnage to as much as 1 million tons PAG waste rock, subject to the existing mitigation measures and criteria, for mining within the approved plan of operations boundaries, for development and mining within the proposed interim expansion areas, and for mining of the full 3070+ expansion area, provided that crown pillar mining widths stay approximately within those already evaluated (up to 215 ft in Zones 1 and 2, about 60-130 ft. in Zones 3, 4, 5 and 6).

Mining Coordinates and Depths

- Removal of ore above the 3070 ft. elevation in upper Zone 2 in seven lifts of drift and fill mining, between coordinates 7200E and 7600E; 25850N and 26400N; between elevations of 3085 to 3200 feet, as shown in **Figures 5, 6, 7**.

- Mining in Zone 4 extension (Zone 4E); primary development and mining in Zone 6 extension (Zone 6E) between 6500E and 7000E; 27500N and 27850N; between elevations of 2160 to 2650 feet, as shown in **Figure 5**.

- Approximately 1500 feet of ramp construction in Zone 7, between 6400E and 7000E; 27100N and 28000N; between elevations of 2100 feet and 2225 feet, as shown in **Figure 5**.

- Extend an exploration drift northward into the "north" North Lamefoot ore zone and perform exploration drilling to delineate potential PAG waste rock tonnages. Extend an exploration drift down into the new Zone 7 and perform exploration drilling to delineate potential PAG waste rock tonnages. Both drifts would be aligned approximately parallel to and underneath the overlying 2225N drift. Perform permeation grouting in advance of both drifts to minimize water seepage and inflow in accordance with the 11/30/94 ROD, Section IV.E and described in the approved Plan of Operations.

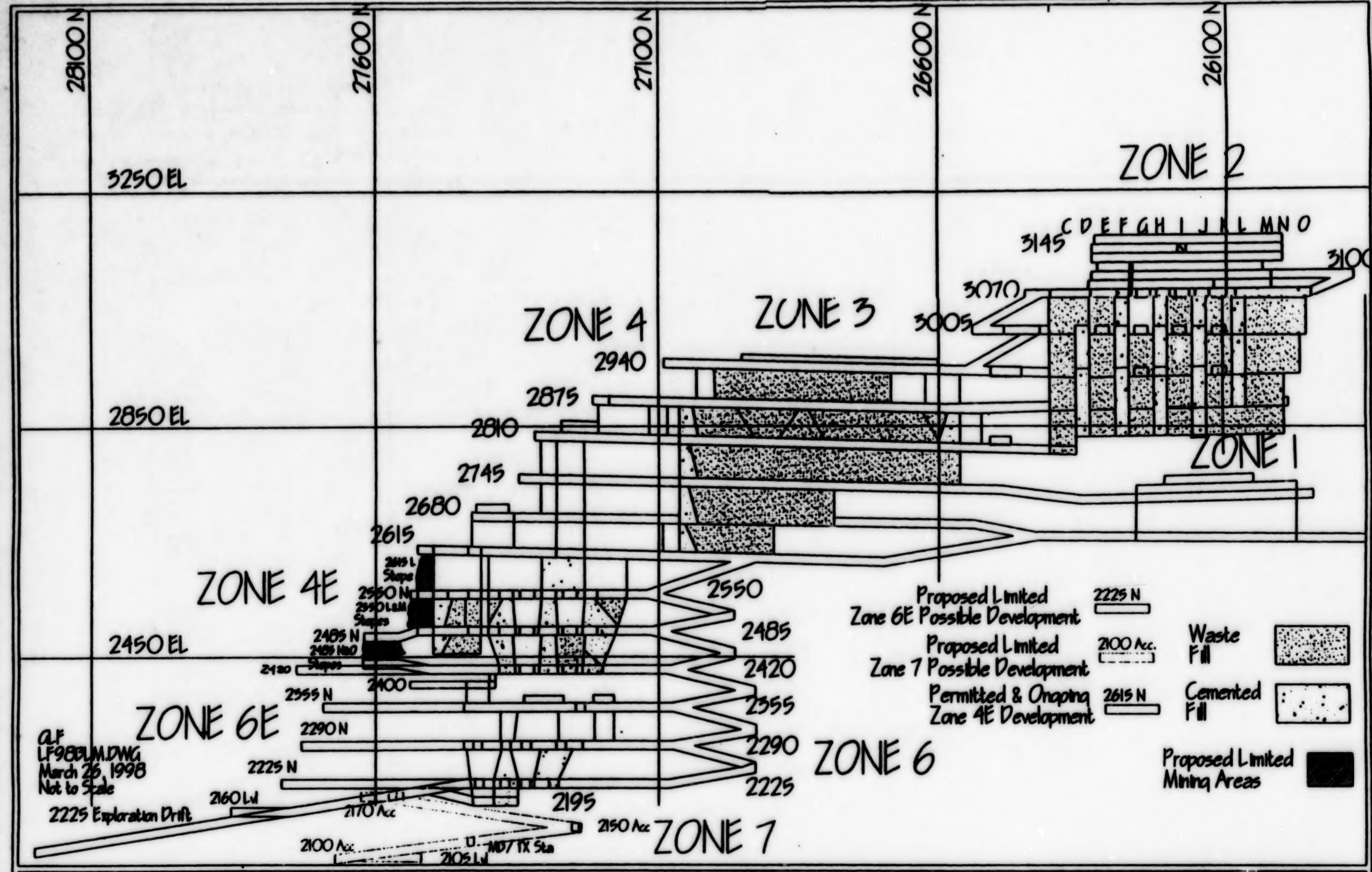

Figure 5. ALTERNATIVE 2 - ENLARGED INTERIM EXPANSION. Longitudinal section illustrating possible mine workings. Zone 2 (3070+w/7 levels), Zone 4E Mining Expansion, Zone 6E Mining Expansion

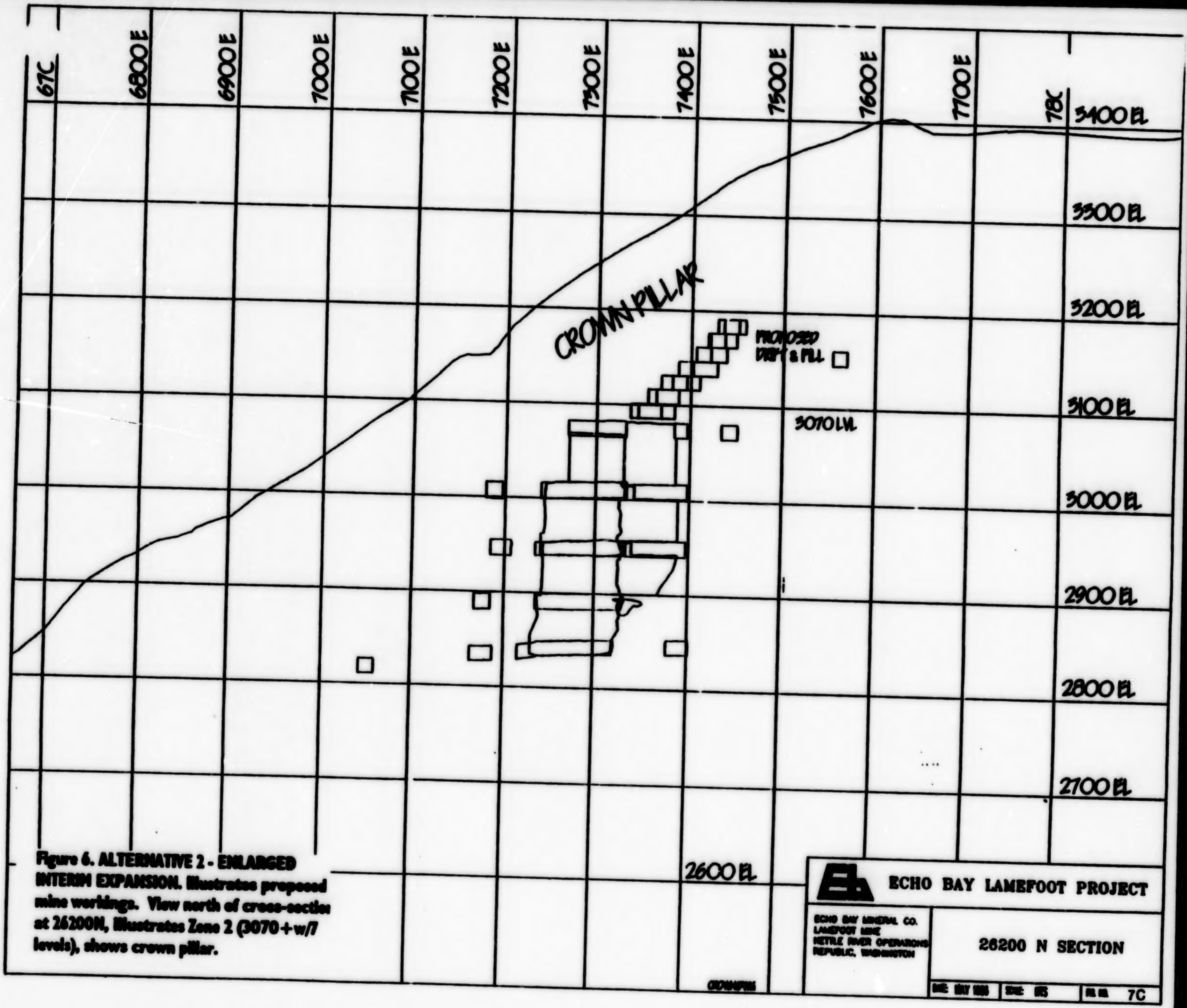

Figure 6. ALTERNATIVE 2 - ENLARGED INTERIM EXPANSION. Illustrates proposed mine workings. View north of cross-sectio at 26200N, Illustrates Zone 2 (3070 + w/7 levels), shows crown pillar.

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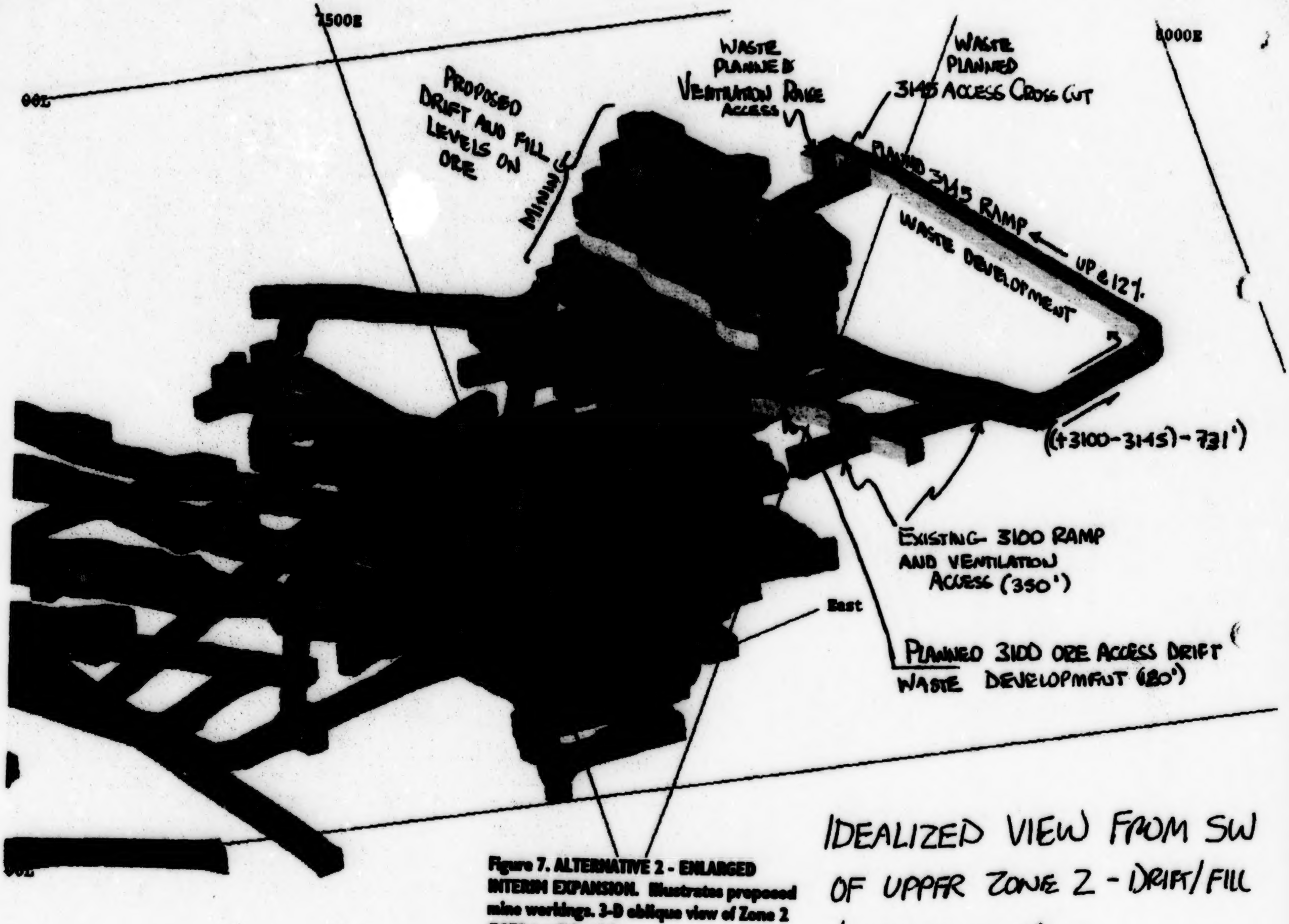
1500E
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PROPOSED DRIFT AND FILL LEVELS ON ORE
MINING
WASTE PLANNED & VENTILATION RAISE ACCESS
WASTE PLANNED 3145 ACCESS CROSS CUT
PLANNED 3145 RAMP
WASTE DEVELOPMENT
UP @ 12%
((+3100-3145) - 731')
EXISTING 3100 RAMP AND VENTILATION ACCESS (350')
East
PLANNED 3100 ORE ACCESS DRIFT WASTE DEVELOPMENT (180')
00L

Figure 7. ALTERNATIVE 2 - ENLARGED INTERIM EXPANSION. Illustrates proposed mine workings. 3-D oblique view of Zone 2 (3070+w/7 levels).

IDEALIZED VIEW FROM SW OF UPPER ZONE 2 - DRIFT/FILL LAMEFOOT MINE

5.0 AFFECTED ENVIRONMENT

The overall project area boundary remains essentially the same as shown in **FEISS Figure 1-2**, as modified by the 9/20/95 EA which substituted the Corl Gravel Pit for the quarry identified in the FEISS. The Affected Environment relative to the following items remains essentially the same for the Proposed Action and Alternatives, with no substantive differences from the descriptions in the Lamefoot Mine Final EISS, Section 3.0 for: Transportation, Noise, Soils and Reclamation Potential, Air Resources, Recreation, Socioeconomics, Cultural Resources (including Native American Religious Concerns), and Vegetation. There are no Areas of Critical Environmental Concern, prime or unique Farm Lands, floodplains, Wild & Scenic Rivers, or Wilderness involved in or affected by the actions. The EA includes current descriptions of the affected environment where new information is available and where ongoing monitoring identified changes in the affected environment.

5.1 GROUNDWATER

New information collected by the studies in 1997 has corroborated some of the previous interpretations and resulted in some new interpretations of the groundwater system relative to 1994/95 interpretations about the natural water levels, quality and water movement in the vicinity of the mine. The information also further refines the information on background water quality and identifies the pre-mining water elevation (**Figure 8**) and the current extent of groundwater drawdown impacts resulting from mining and exploration operations (**Figure 9**).

Two new monitoring wells (LF-13 & 14) have been drilled, completed and tested and will be used for characterizing groundwater conditions and tracking potential future outflows from the northern end of the mine from the existing mine and proposed expansion areas. Water inflows to the 2225N drift have been tracked during extension of that exploration working. Discharge tests have been conducted to investigate greater water flows encountered by exploration drilling from the 2225N drift in the same area as the proposed mine expansion, and these flows have been determined to be primarily related to the Wolf Camp/Gravel Pit and Anfo faults. Monitoring data was also reviewed for groundwater monitoring wells, surface water monitor sites at four wetlands, and one spring.

5.1.1 GROUNDWATER DRAWDOWN AND QUANTITY

The FEISS estimated that the groundwater level was at about the level of Wolf Camp valley prior to mining (i.e., at about the 2750 ft. elevation). The 1995 studies ("2750 Report") indicated that the pre-mining water level was actually close to the surface throughout the mine area, and that the water table remained close to or at the ground surface within the project area, except where the mine had made a local drawdown cone. The 1995 studies identified that about 300 ft. of drawdown had occurred, and the 1995 hydrologic model predicted that the mine would refill and the groundwater level would be re-established almost to pre-mining levels about 50 years after the mine closes. The 1997/98 studies show that groundwater drawdown of about 600 ft. or more currently extends down to the elevation of the lowest workings. Operations have locally dewatered an area up to about 3200 ft long and up to about 700 to 1000 ft. wide in a narrow zone around the footprint of the mine workings and exploration drift.

5.1.2 GROUNDWATER MOVEMENT

The FEISS identified two types of groundwater flow that exist in the vicinity of the mine. Near surface alluvial deposits overlie bedrock between the mine and Curlew Lake. The alluvial deposits are porous medium with a relatively high permeability that can transmit water relatively quickly. Flow through alluvium comes mainly from surface infiltration and runoff (e.g., rainfall). In contrast, the bedrock is a fracture system where most water flows through the fractures. The rock mass is relatively impermeable and only a small amount of water moves directly through the rock.

The FEISS estimated that mine workings might

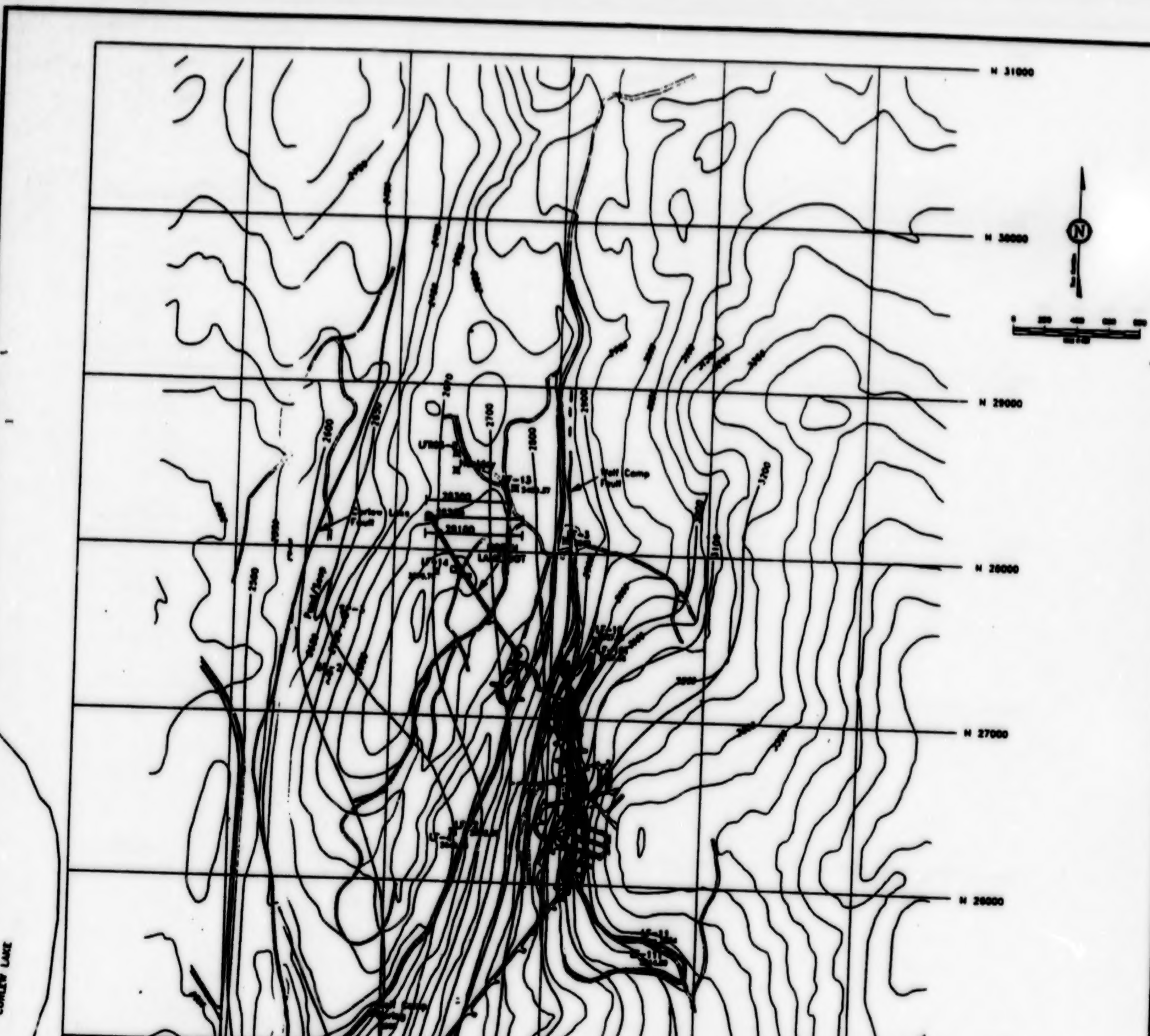


Figure 8. PRE-MINING WATER ELEVATION. Potentiometric surface map illustrates the approximate pre-mining water elevation contours and gradient.

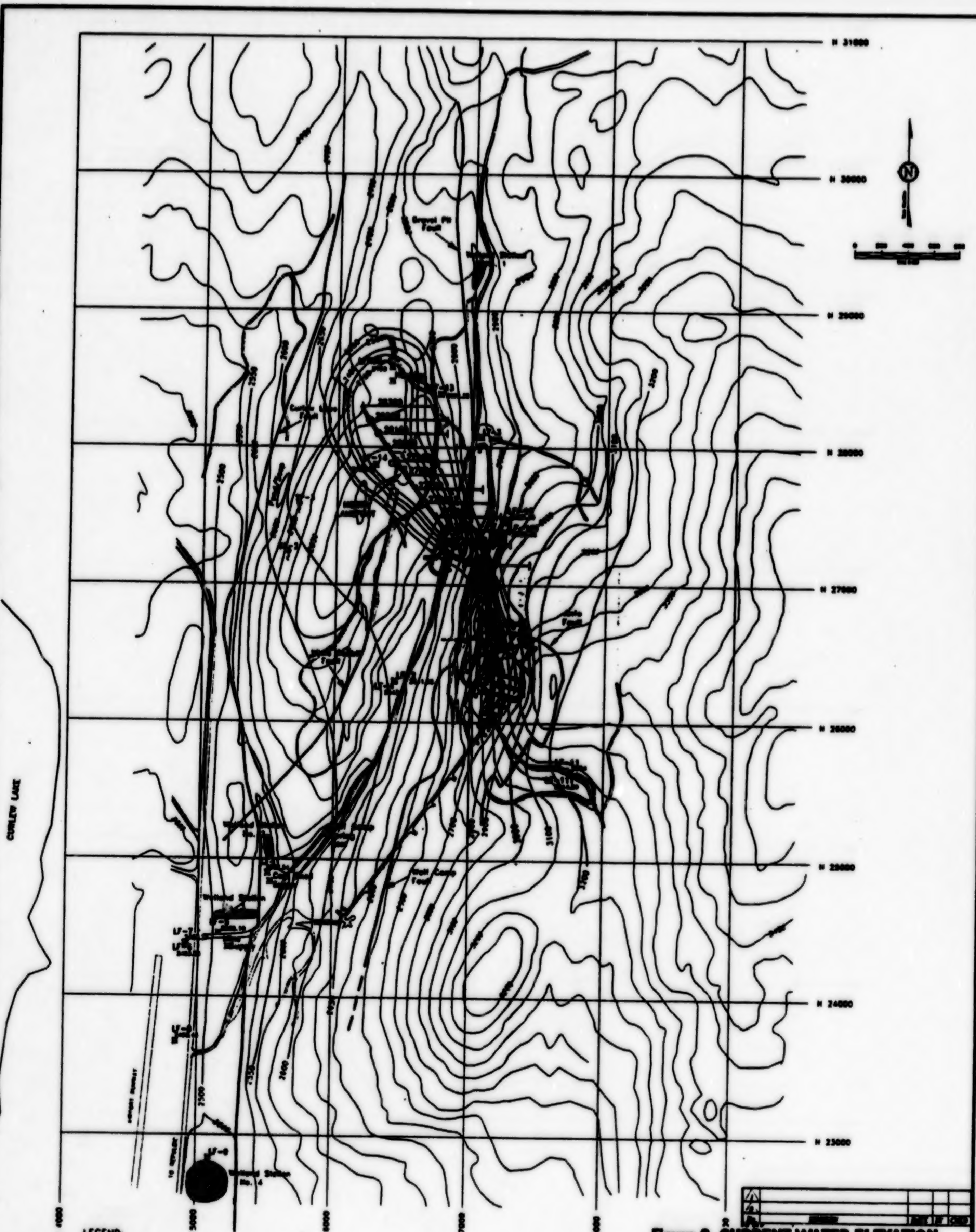


Figure 9. CURRENT WATER ELEVATION. Potentiometric surface map illustrates approximate water elevation, contours and gradient. Shows narrow drawdown area surrounding existing mine workings.

encounter fracture zones with localized higher groundwater flow rates, and that these zones might transmit water along localized pathways. The FEISS also noted that a zone of silicification reduced the permeability in the vicinity of the mine workings by locally sealing fractures, suggesting that permeability might be greater outside that silicified zone. Extensive vertical and horizontal drilling was conducted in 1995 to test this possibility.

The 1995 studies indicated that the bedrock in the mine vicinity south and east of Wolf Camp valley was less permeable than estimated in the FEISS and this has been substantiated by monitoring since 1995. The less permeable zone generally extends as far north as mine coordinate 27600N. The 1995 studies found that water moves directly through the rock so slowly that mine wall surfaces only become moist if the ventilation is turned off because the air movement from ventilation evaporates about ten percent of the inflow. As a result, rocks within the upper parts of the mine appear to be almost dry throughout much of the year, and dewatering creates a local cone of depression that is limited to the area in close proximity to the mine. The 1995 studies measured about a one gallon per minute (gpm) loss of moisture to the ventilation system; since mine workings have substantially increased in size since then, the moisture loss from ventilation may have increased to about 2 gpm or more. Direct measurements have shown that the pre-mining saturated zone was close to the ground surface, instead of at the 2750 ft. msl elevation projected by the FEISS.

The 2750 Report indicated that fractured zones tended to be limited in size, and most fractures only transmitted a small amount of water. Localized fracture zones with greater flows were identified with hydraulic conductivities up to about 104 ft./yr. (10^{-4} cm/s) (Table 2), but the 2750 Report indicated that it appeared less likely that any high flow zones will be encountered by mine workings. The 2750 Report found a small increase in permeability outside the silicified zone surrounding the mine workings, but found that low permeability conditions and slow groundwater movement in bedrock predominated throughout the vicinity of the workings south and east of Wolf Camp valley.

Table 2. RELATIVE CAPACITY FOR RATE OF WATER MOVEMENT (hydraulic conductivity)*

	Local Fractures	Overall Rock Mass
FEISS	**---**	**33 ft./yr.**
9/20/95 EA	**50-300 ft./yr.**	**0.25-1.6 ft./yr.**
1998 EA	**300-1100 ft./yr.**	**0.25-1.6 ft./yr.**

*** Gives comparison for different capacities identified by each study. Actual rates of flow also depend on other factors. Actual rates of flow, especially for fractures, would likely be substantially less than indicated over a long distance.**

The 1997/8 studies for the North Lamefoot area (i.e., areas north of the 27500N coordinate) encountered fractures with greater capacity to transmit water than previously indicated in the 2750 Report. Hydraulic conductivities for fractures are in the range of 104 ft./yr. to 1035 ft./yr. (10^{-4} to 10^{-3} cm/s) in North Lamefoot, instead of the upper range of 10 ft./yr. to 104 ft./yr. (10^{-5} to $10^{-4)}$ cm/s found by the 1995 studies for areas south and east of the Wolf Camp valley. The greatest flow capacity about 1100 ft./yr.(28)(10^{-3} cm/s) was found at the bottom of monitor well LF-14 which was completed in the 5 foot wide Wolf Camp fracture zone that dips steeply westward toward Curlew Lake.

From September to October, 1997, new exploration holes along the 2225N exploration drift were started as soon as the previous holes were completed. The new holes started at the north end of the drift, progressed southward, and encountered water over a 700+ foot length zone from about the 28300N to the 27600N coordinates. Drill holes were open into several water zones and producing water during drilling operations for over a month prior to the time discharge tests were conducted. As a result, much of the drawdown had occurred before testing was conducted, so actual flow rates were probably greater than estimated.

Some of the highest flow rates were encountered in the earliest holes in the 2225N exploration drift and flow rates were not measured at that time, but subsequent testing about a month later measured up to about 50 gpm. At the time of testing, drawdown had considerably lowered water elevations by as much as 430 to 600 feet. The tests were conducted on five holes simultaneously over a two hundred foot interval with a head of about 107 feet producing a combined discharge of about 239 gpm that declined to about 11 gpm in less than 2 hours. When the water zone was initially encountered by the first drilling operations, the head was over four times greater, so the initial flows probably exceeded 50 gpm per hole. In general, the 1997/98 studies indicate the increase in flows appears to be related to more permeable fractures and the greater head at depth. The magnitude of flows can be an important consideration in carrying out grouting operations. The discharge tests identified hydraulic conductivities of 104 ft./yr. (10^{-4} cm/s) and comparatively limited water storage capacity within the fracture zones. Continuing drawdown has since lowered water levels down to about the 2100 ft. msl elevation of the 2225N exploration drift (Figure 9).

No drawdown impacts to surface water in wetlands have been identified to date, but changes in the monitoring system are scheduled to correct data gaps since 1996.

5.1.2.1 CHANGES TO GROUNDWATER MOVEMENT BY EXISTING GROUTING

The proposed action in the FEISS, Section 2.3.5, proposed grouting as a means to seal boreholes and fractures that might provide pathways that would allow mine waters to exit the mine. This proposal was analyzed in the FEISS and a more effective approach was required by the 11/30/94 ROD, Section IV.E. Grouting was intended to alter the groundwater movement into and through the site and change the Affected Environment pre-mining conditions as a control measure. As such, these measures would revise the Affected Environment relative to proposed expansions. However, implementation records are lacking details so there are now some uncertainties about when, where and how grouting has been performed to date.

The FEISS and the 9/20/95 EA conclusions were based on the data indicating that the bedrock surrounding the mine was very impermeable and would likely contain any degraded mine waters within the mine workings if boreholes and fractures are sealed to reduce and eliminate connections and potential water pathways.

The 11/30/94 Record of Decision required a more effective method of grouting of boreholes and fractures to ensure that grouting provides a consistent seal of all mine workings and minimizes potential sources of outflow of mine waters. Verification by an independent registered professional engineer grouting specialist was required to ensure that permeation and borehole grouting is performed in an effective manner.

In 1994, EBM planned to grout 494 holes. Shift records verify that grouting was performed during 1994, but the records typically only identify the general mining level where the work was performed and typically do not identify the specific drill holes involved or the grouting methods used. This initial grouting under the exploration program prior to the 11/30/94 ROD presumably used the methods presented in the proposed action in the FEISS. The grouting probably used Portland cement, which could deteriorate over time when exposed to mine water with high sulfate concentrations.

However, there are discrepancies about whether all holes were grouted. In 1998, EBM reviewed their records and identified that 150 surface holes may have been grouted or plugged in 1993, and 391 underground holes may have been grouted in 1994 for a total of 541 holes. The discrepancy is important because even one ungrouted hole located in a place that establishes a direct connection between the mine pool and the surface or near-surface in the valley could potentially provide a pathway that could allow release of enough mine water to cause an impact outside the project area boundary.

EBM also reported that grouting was not performed underground from 1994 until early in 1998, when grouting operations began again. At that time, at least 37 underground holes had been left ungrouted with packers installed instead to provide underground water sources. One former underground monitor hole (LFC-432) into the shallow subsurface under Wolf Camp valley had a valve installed and may not have been grouted, but the location is now reported to be inaccessible. EBM is also performing inspections of surface hole locations and has reported that a few open holes were left open for geotechnical or other reasons, but that most holes located to date have been plugged. EBM is continuing the record check and inspections and will provide a report later this summer.

The number of holes drilled since 1994 has not been identified, but there has been extensive drilling that may involve as many as hundreds of additional underground and surface boreholes and grouting of these more recent holes has not been verified. As a result, a high potential may exist for interconnections that could allow outflow of mine waters after the mine refills, including possible direct discharge to the surface or near-surface with essentially no attenuation.

5.1.3 GROUNDWATER INFLOW TO MINE

Underground seeps and overall inflow exhibit a strong seasonal pattern. Peaks in inflow correspond to the spring runoff season, resulting in noticeable increases in inflow through the crown pillar. Several hundred boreholes were grouted during 1994, which reduced flow into the mine at that time.

Inflow estimates have varied. The 2750 Report identified that minimum water inflow was 1 gpm, peak inflow was about 20 gpm, average inflow was about 6 gpm and the inflow appeared to be decreasing. Subsequent review of monitoring data indicates that the inflow actually appears to have increased as mine workings have expanded in size. Minimum inflow is about 1 to 5 gpm, but peak inflows have ranged up to about 60 gpm (Figure 10) and the average monitored inflow is about 16 gpm.

However, monitoring does not record all inflow. The 1995 studies noted that about 1 gpm was lost to evaporation from the ventilation system. Mine workings have increased substantially in size since then, and losses to evaporation may now be about 2 gpm, so total average inflow has increased from about 7 gpm in 1995 to about 18 gpm in 1996-1998.

5.1.4 GROUNDWATER QUALITY

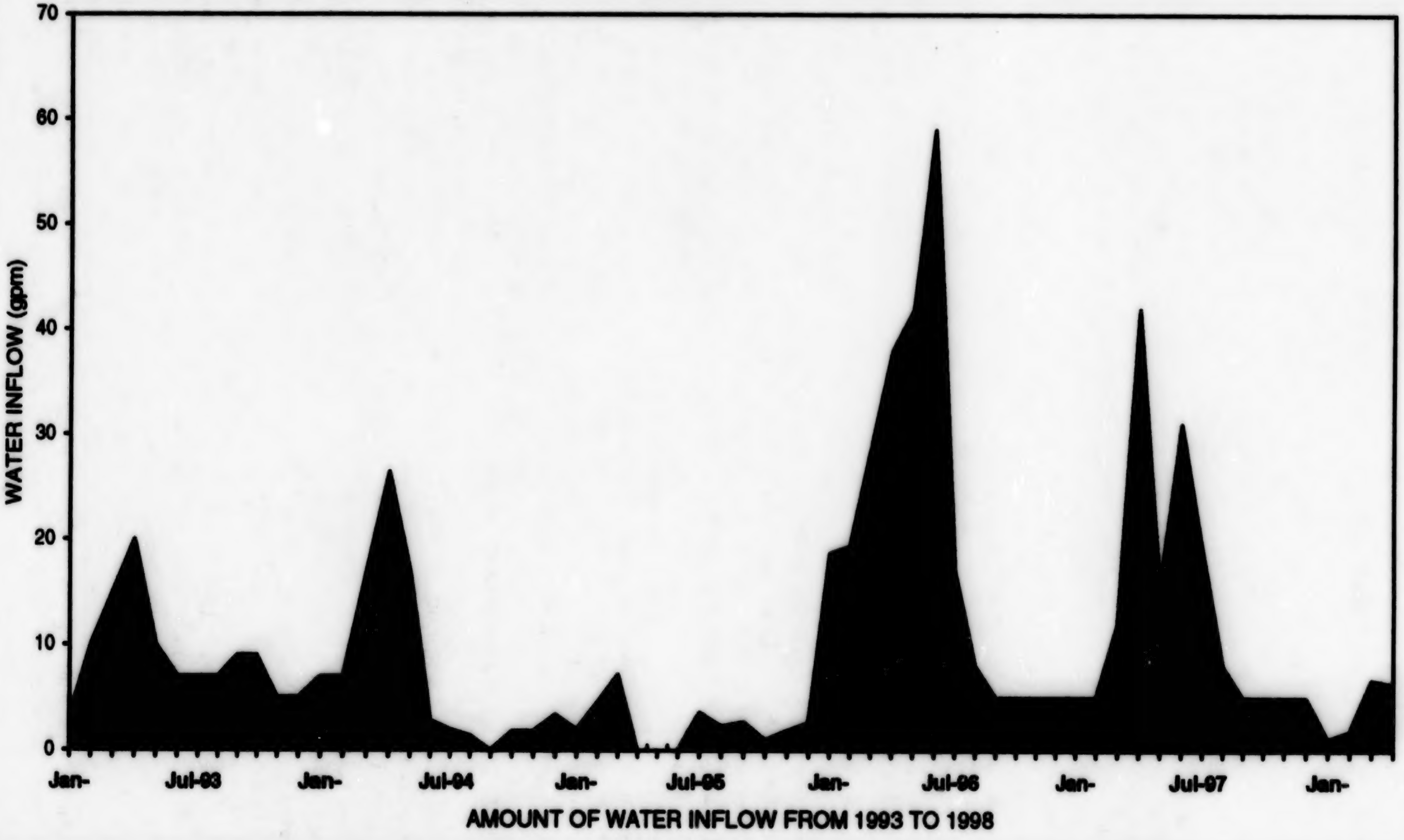
Background groundwater quality outside the boundaries of the mineralized zone is generally moderate quality and falls within state water quality criteria for drinking water. Water quality at the State park is generally good, but is reported to have occasional coliform contamination.

The groundwaters in the project area have neutral to slightly alkaline pH's, with moderate concentrations of total dissolved solids and generally undetectable concentrations of most trace metals. The waters are divided into three distinct types related to their location in either valley fill alluvium, limestone bedrock or clastic bedrock. Naturally-occurring nitrates are present in only low concentrations in background groundwater. Washington groundwater standards recognize that natural groundwater quality may exceed the numerical criteria in the groundwater standards. Some constituents occur in higher concentrations in a zone around the naturally-occurring mineralization from the ore deposit.

Sulfate is noticeably elevated in the vicinity of the ore deposit due to natural near-surface oxidation of the sulfide mineralization. Sulfate concentrations at the ore deposit naturally ranged up to 610 mg/l prior to mining, and manganese concentrations ranged up to about 0.215 mg/l, both of which exceed secondary drinking water standards. Traces of barium, iron, manganese, copper, and zinc are present locally in detectable concentrations. In and near the mineralized zone

Figure 10. MINE WATER INFLOW HISTORY. Illustrates the pattern of water inflow into the mine. Grouting of numerous boreholes took place in 1994 within mine workings in existence at that time.

Lamefoot Mine
Monthly Water Inflows



Data compiled from the 2750 Report Impact Evaluation, June/July 1995, the Impact Evaluation, May 1998 (as revised June, 1998) and monthly monitoring reports (note: data not available for some months in 1994 and1995).

there are slightly higher detectable background concentrations of arsenic and selenium. Many monitor wells are within the natural zonation and have background water quality that is naturally elevated in some constituents from proximity to the mineralized zone. Natural water quality exceeds numerical criteria for groundwater standards in most wells for one or more of the following: TDS, sulfate, zinc, manganese, fluoride, arsenic, lead and iron (FEISS, Section 4.3.2 and Appendix C-3;(23, 24, 25, 50))

Mine water has maintained a pH of about 7.96 to 8.23, with sulfate levels of up to 826 mg/l, and slightly elevated selenium at 0.02 mg/l.

Some elevated concentrations downgradient from the mine may be related to mining activities, but the specific source hasn't been determined. Groundwater monitoring data indicate that only wells LF-8 and 12 have exceedances of groundwater standards that may be attributable to mining-related activities (elevated nitrate).

Use of explosives in exploration activities up until 1994 may have increased nitrate levels in the vicinity of the waste and ore pads and infiltration pond. In 1994, EBM discontinued use of ammonium nitrate-fuel oil blasting agent and substituted other types of explosives to reduce nitrate levels in discharge water and discharge of mine water into the infiltration pond was also discontinued. From 1994 to 1997, after potential nitrate impacts to groundwater were detected by the monitoring system, EBM hauled water to the mill for disposal in a lined facility.

The Washington Department of Ecology allowed further use of the infiltration pond in 1997, at EBM's request, but recently restricted use of the infiltration pond since nitrate impacts have again been detected by the monitoring system. EBM is investigating to determine if the nitrates are related to any leachate or runoff from the ore and waste rock piles, other mining sources (infiltration pond, septic system, etc.), or non-mining sources.

5.2 SURFACE WATER

The watershed for Curlew Lake and the Lamefoot Mine area are illustrated in Figure 11(37). Surface water within the project area consists of a few springs and wetlands.

A flowing spring (Wolf Camp spring) is located at an elevation of about 2605 ft. along Wolf Camp county road. Flow varies seasonally with high flows from March to July, moderate flows from July to September, and low flows during the winter. Peak flows are about 60 gpm and low flows are about 1 to 3 gpm. Spring discharge flows down slope to provide part of the water in the wetlands at lower elevations. Other small springs also provide flow to the lower wetlands(1).

Cumulative trend analyses(29)(32) of surface water monitoring data are used to refine the FEISS information and evaluate potential impacts.

The spring flows at Wolf Camp spring and water levels at the wetlands appear to be unaffected by mining, even though operations have locally dewatered to the 2225 ft. elevation around the mine, which is below the elevations of the spring and wetlands. Water levels in the wetlands exhibit seasonal fluctuations highs in the spring and lows in the fall/winter of each year.

Four wetlands are monitored for water levels and field parameters at fixed stations that have been accurately surveyed since 1994. Station 1, is the wetland at 2844.5 ft. elev. north of the mine. Station 2, is the wetland at 2532.1 ft. elev. just south of the mine west of the Core Shed. Station 3 is at 2529.7 ft. elevation south of the Core Shed. Station 4 is at 2464.7 ft. elev. south of the ore and waste rock stockpiles.

Wetlands 1, 2 and 3 exhibit seasonal changes in conductivity, with higher conductivity occurring during the spring runoff and lows during the summer and fall. The conductivity values are generally lower than the values in nearby shallow monitoring wells (LF-1 and LF-2). During the same time period, Wolf Camp spring exhibits relatively constant laboratory

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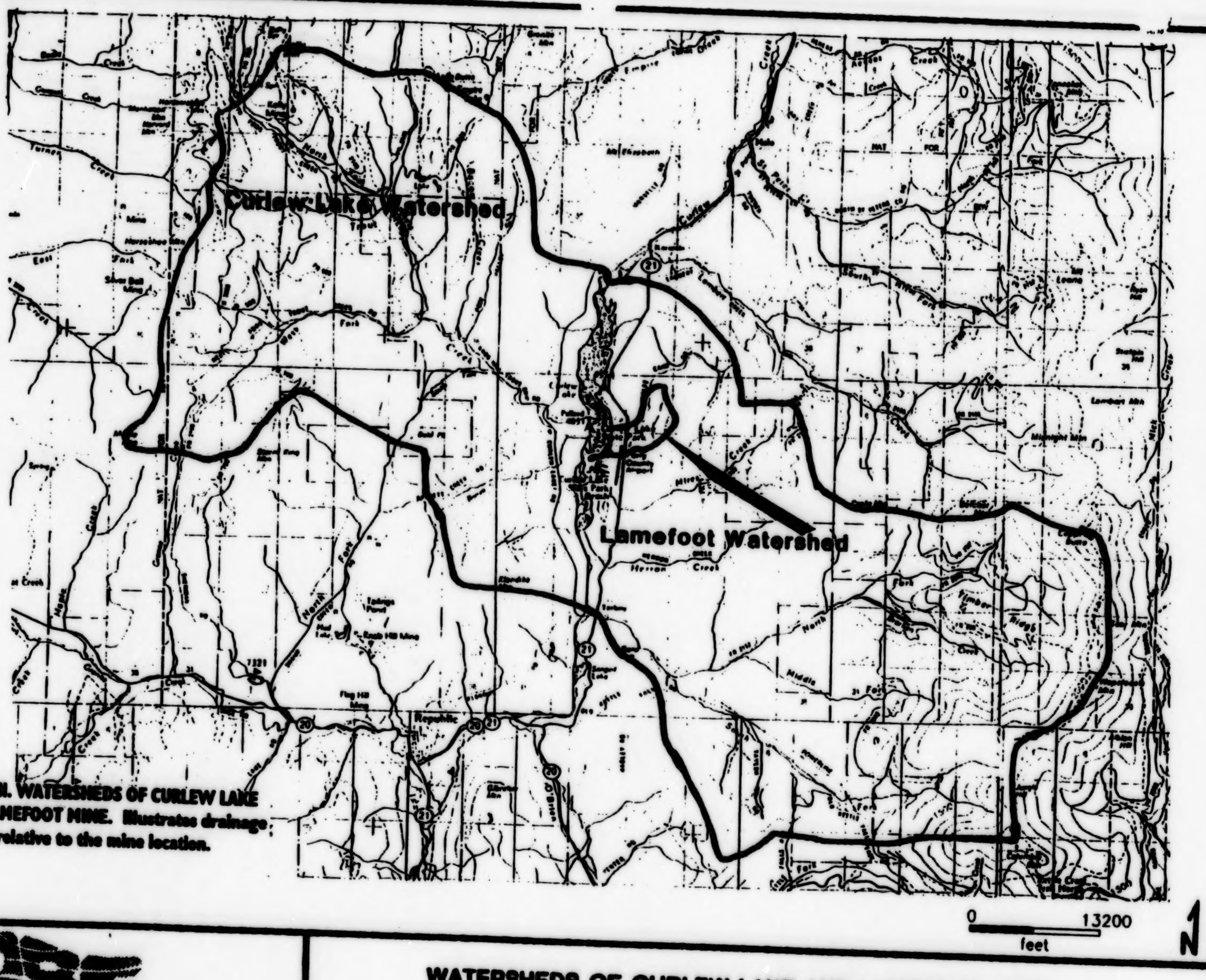

Figure II. WATERSHEDS OF CURLEW LAKE AND LAMEFOOT MINE. Illustrates drainage basins relative to the mine location.

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WATERSHEDS OF CURLEW LAKE AND LAMEFOOT MINE conductivity in a generally similar range of values from about 600 to 800 μmhos/cm.

Contrary to the other wetlands, conductivity values in wetland 4 (below the ore and waste rock stockpiles) exhibits seasonal lows in the spring and seasonal highs in late summer and early fall. The seasonal trend is upward (up to 1900 μmhos/cm). Studies will be undertaken as part of the ongoing monitoring program to determine the cause for the apparent trend. The trends could be the result of evapoconcentration during the summer months.

5.3 GEOCHEMISTRY

The 9/20/95 EA evaluated the geochemistry of the mine environment through the additional studies presented in the 2750 Report. Much of the information from 2750 Report studies corroborated initial findings in the FEISS, but the 1995 studies also helped explain inconsistencies between field observations for the FEISS and the results from the limited range of laboratory tests conducted for the FEISS.

In general, the FEISS found that sulfide content (mainly pyrite) is associated with acid-generating potential and that sulfides are present throughout the mine. Acid-generating potential was primarily associated with two rock units (clastic and altered limestone; 44% and 36% of wall rock, respectively). In general, most of the clastic rocks and the high sulfide zones in the altered limestone were considered to have potential for acid-generation. The remaining rock types in the Lamefoot Mine were typically neutralizing to highly neutralizing in character.

The 2750 Report confirmed the initial FEISS characterization of the rock types in the mine that have potential for acid generation and high sulfate levels, and provided further information that defined and explained the reaction rates that indicate that time is an important factor at this site. Laboratory tests found low to moderate reaction rates for the clastic and altered limestone rocks indicating that there would be a long lag time before acid-generating reactions consumed the neutralizing materials. Microscopic evaluation indicated that even high sulfide rocks contain neutralizing minerals that surround the sulfide particles. Acid-generation at the microscopic level results in an immediate reaction with the surrounding neutralizing material. That neutralizing reaction coats the sulfide particle with iron which further slows the acid-generating reaction rate. This self-inhibiting nature slows the reaction rate for net acid-generation, and was observable in field studies.

The 1995 studies tested the extent of wall rock reactions in old prospect areas in the Lamefoot Mine exposed for 60 years and compared that to areas exposed by exploration for only a few years. The wall rock tests generally corroborated the rates indicated by the laboratory tests. In most places, recently exposed rocks with high sulfide content typically do not generate acidity. Similar rocks exposed for a long time exhibit lowered pH, particularly where sulfides are exposed to water from seeps. The reaction rates observed indicate that many years of exposure are needed before water quality begins to deteriorate due to pyrite oxidation reactions which corroborates the laboratory kinetic tests that indicate there will be a long lag time before the inherent neutralizing capacity of the rock is consumed and the water pH is lowered.

Conditions during mine operations are less conducive to acid generation because ventilation dries the mine wall surfaces. However, as the mine re-saturates after closure and groundwater levels rise in the vicinity of the mine void, wall rocks throughout the mine are expected to become moist, humidity will increase, and the conditions will become more conducive for acid generating reactions.

In the 1995 studies, drilling from the surface above the mine identified that pre-mining oxidation only extended down to about 30 feet to the upper portion of the zone that was saturated by groundwater prior to drawdown. The 1997 subsidence study indicated that initial and continuing rock mass displacement in the crown pillar results from mining, and this would have already increased opening of fractures in the crown pillar. This may result in increased permeability and greater pyrite oxidation along these fracture surfaces. If the crown pillar remains perpetually exposed to oxidation due to drawdown effects, acid-generation may gradually increase locally over time and penetrate further into the crown pillar. However, there may also be counter-balancing effects, since the slow penetration of the oxidation into rock surfaces suggests that over a very long time period (tens or hundreds of years), the rate of oxidation may gradually stabilize or decrease as sulfide minerals near fracture surfaces become oxidized.

The 1995 studies tested seeps within the mine to evaluate actual conditions, and the majority of seeps had neutral to alkaline pH. The chemical composition of the seep water typically indicated either neutral to alkaline conditions or neutralized acid-generation, such as at the LFC-120 borehole on the 2615 Level used for the current geochemical model.

Where acid generation occurs in the mine, it is typically neutralized within the bedrock by groundwater and other mine rocks, but a few low pH seeps were found. For instance, an exploration drift near the top of the mine exposed a natural solution cavity formed by a seep with an acidic pH of 2.2 to 2.5 (conductivity 1000-8130 umhos/cm), while some other seeps and wall test areas elsewhere in the mine exhibited pH in the 4 to 5 range. Water at these locations had elevated concentrations of dissolved constituents. A few solution cavities were also observed at other locations in the mine workings, indicating that there may have been some localized pre-mining acid generation within mine rocks, but those cavities had been dewatered by the mine workings. Seep monitoring data shows elevated and variable conductivity values (1000-3200 umhos/cm) on numerous mine levels, which may result from neutralized acid-generation reactions.

While information on current water quality is useful in evaluating long-term predictions about the rate of acid generation, the current overall water quality of seeps from recently exposed walls is not indicative of the future water quality from the same locations if drawdown persists for an extended period of time. In general, the laboratory and field tests corroborate the FEISS predictions that, "Water quality within the mine workings during the operational phase will be somewhat degraded relative to background. ... It is assumed that water in the mine workings during the operational phase will have a pH above 6.5 (probably between 6.5 and 8.0)." (FEISS, Section 4.3.2, p. 4-11).

The 1995 studies conducted tests to simulate the effect of flooding on the geochemical reactions of water with the waste rock and wall rock. These tests indicate that the waste rock becomes oxidized while exposed to air, but suggested that the reactions will diminish after the rocks are submerged for some time. Coatings may form on the rock surfaces and may reduce the reactivity of the neutralizing components, the acid generating components or both. The presence of iron oxide and gypsum coatings were observed during the 1995 studies.

The 1995 studies also conducted tests to determine the capacity for bedrock and alluvium to attenuate, or remove, dissolved constituents from groundwater that might originate from the mine. Those tests indicated that neutralization is effective in removing most dissolved constituents that are likely to have elevated concentrations in the mine water.

Most of the clastic rocks and much of the altered limestone rocks have potential to generate acid. Overall, up to 60-80% of the exposed wall rocks and crown pillar may have some potential to generate acidity and high sulfate concentrations, but at a slow to moderate rates. However, since even the rocks with the highest acid generating potential also have a substantial neutralizing component, a long time period would be required before the neutralizing capacity is consumed. In addition, existing mitigation measures add a substantial amount of neutralizing capacity to the backfill, and the cemented backfill reduces the rate of sulfide oxidation as well as neutralizing acidity(49). Maintaining an elevated pH assists in maintaining water quality of the mine water.

The 9/20/95 ROD requires that over 50% of the potentially acid-generating rock be placed in cemented fill. In February 1997, only about 41% of the potentially acid-generating rock had been placed in cemented fill but that amount has since been increased to about 51%. The 9/25/95 ROD and EA were based on estimates that only 9% (164,300 tons) of the total backfill would be PAG waste rock out of about 1.8 million tons of backfill. However, as of May, 1998, a total of about 1.22 million tons of backfill has been placed in the mine and about 36% (442,600 tons) is PAG waste rock. Since about one year of mining still remains within the previously authorized boundaries, the amount of PAG waste rock is expected to increase over current totals.

5.4 GEOLOGY AND SUBSIDENCE

As noted in the FEISS, backfill provides support to prevent subsidence of the ground surface after mining. Two kinds of backfill are used - cemented fill and loose fill. Cemented fill provides support during mining operations and creates a safe working environment for the miners. Loose fill occupies the majority of space for long-term subsidence control and minimizes the potential amount of movement.

During the FEISS, the mine waste rock was evaluated for use in cemented fill and determined to be suitable for that purpose. Cemented fill would be constructed almost entirely from mine waste rock. As evaluated in the 9/30/95 EA, the Corl gravel pit was substituted for the Wolf Camp quarry because it can minimize the amount of sulfides in the backfill. The Corl gravel does not bond well with cement, and is used for loose fill but it does compact well and provides strength comparable to the materials evaluated in the FEISS.

About 1.22 million tons of backfill have been placed to date, including about 453,600 tons of cemented backfill. Mining has extended up to the base of the crown pillar in many locations east of Wolf Camp valley. No subsidence of the ground surface has been detected by the monitoring that has been conducted since 1994.

5.5 AESTHETIC RESOURCES

Aesthetic resources are the same as described in the FEISS (Section 3.5), as modified in the 9/20/95 EA, which analyzed the impacts of substituting the Corl gravel pit for the quarry that was originally proposed in Wolf Camp valley. The Corl gravel pit is within zones along State Highway 21 identified as having Class III Visual Resource Management objectives. These objectives include moderate change which partially retains the existing character of the overall landscape.

As noted in the FEISS, the area adjacent to State Highway 21 is considered to have a high visual sensitivity. The Corl site is located entirely on private property immediately south of the Lamefoot Mine on the hillside east of State Highway 21. The Corl site has been developed in a manner which screens most disturbance from view, and visible portions are oriented to minimize visual impacts.

5.6 WILDLIFE

Information relative to general wildlife and special status species is essentially the same as that described in the FEISS. An informal consultation process under Section 7(a)(2) of the Endangered Species Act was initiated as part of the FEISS. BLM's original biological evaluation was submitted to the U.S. Fish and Wildlife Service on November 2, 1993, identifying BLM's determination of "not likely to adversely affect" for the gray wolf, grizzly bear and bald eagle. A "no effect" determination for peregrine falcon was made by BLM due to the lack of suitable habitat for this species within the project area. The FEISS specifically addressed Canada lynx and northern goshawk. FWS issue a letter of concurrence dated January 26, 1994.

However, since 1994, the Canada lynx (lynx canadensis) has been proposed for listing as threatened. Bull trout (salvelinus confluentus) has been listed as threatened. The northern goshawk (accipiter gentilis) is a species of concern. Therefore, the BLM conducted an analysis([illegible]) of potential effects that will serve to update the original biological evaluation and fulfill the requirements under the Endangered Species Act (ESA) and BLM policy. Should Canada lynx become federally listed during the life of the Lamefoot Mine, the biological evaluation would further serve to amend the original informal consultation under Section 7(s)(2) of the ESA.

The Lamefoot Mine is operating outside of the current primary Canada lynx range as delineated by the Washington Department of Fish and Wildlife, and lynx occurrence has not been documented on or in the vicinity of the project area. Habitats within the project area lack habitat characteristics which would be classified as foraging habitat, denning habitat, or linkage habitat.

The Lamefoot Mine is not located in an area currently occupied by bull trout. Neither Curlew Lake nor Curlew Creek are identified as recently or historically identified bull trout habitat.

The Lamefoot Mine is located within the range of the northern goshawk, which is currently described as west of the 100th meridian. There are no nest sites or territories identified within the project area or in the vicinity, and although habitat is present, it is considered marginal for nest sites development.

6.0 ENVIRONMENTAL CONSEQUENCES

6.1 INTRODUCTION

Impacts relative to: Transportation, Noise, Soils and Reclamation Potential, Air Resources, and Cultural Resources would be similar in intensity and effect to those described in the FEISS, Section 4.0 and the 9/20/95 EA (Environmental Consequences), and these impacts would continue and be extended for the time periods involved in the proposed action and alternatives.

See Appendix A for a table comparing the overall results and conclusions about water resources from the FEISS, the 1995 studies and EA, and the 1997/8 studies and EA.

6.2 GROUNDWATER

6.2.1 Proposed Action

The proposed action involves continuing mitigation analyzed in the FEISS and 9/20/95 EA, and required in the 11/30/94 and 9/20/95 RODs and the approved plan of operations, and applying those measures to new expansions.

Regardless of the theoretical effectiveness that could be achieved by the required mitigation, actual mitigation is only as effective as its implementation. Therefore, the analysis also considers the monitoring data collected to date.

Groundwater studies were updated to identify the potential impacts to groundwater and wetlands to date from drawdown of groundwater surrounding the existing mine workings. Water quality monitoring data was also reviewed. Additional studies were conducted to evaluate increased water flow in new fractures encountered in the underground exploration areas at the north end of the mine. These areas have ten to a hundred times greater hydraulic conductivity (i.e., capacity for water movement) than found during the 1995 studies. The 1997/98 studies examined the possibility of preferential pathways for water movement out of the project area along faults and fractures.

The FEISS, Section 4.1.2.1 (p. 4-3) predicted that inflow might increase about 12.2 gpm through the crown pillar due to subsidence effects from full development of stopes, bringing total inflow to about 17.4 gpm.

A 1997 subsidence analysis(16, 17, 18) (Section 6.5) identified that rock mass displacement in the crown pillar during and after mining might be great enough to allow a substantial increase in water movement through the crown pillar where fractures are connected.

As a result of the technical review findings and the subsidence model, the hydrology model was re-examined to determine how it had addressed water flow through the crown pillar. The 1995 hydrology model projected complete refilling of the mine after closure, but the 1995 hydrology analysis did not project any substantive increase in water flow through the crown pillar and the bounding conditions and orientation of the hydrology model would not have taken into account water movement through the crown pillar.

Therefore, the hydrology model was revised to evaluate potential pathways for release of mine water along the west side of the mine and the potential impact to wetlands due to groundwater drawdown during and after mining. The revised model analyzes the possible effects of increased water quantities flowing into and out of the mine through the crown pillar and faults. The revised model analyzes the possibility that crown pillar increases in permeability and/or other pathways (faults, fractures, boreholes) for outflow may be great enough to allow essentially all inflow to the mine to exit into Wolf Camp valley.

6.2.1.1 GROUNDWATER DRAWDOWN

Monitoring shows that the mine workings have progressively dewatered the surrounding area as the mine has deepened. Studies indicate that the inflow to the southern part of the mine is limited due to the low permeability of the rock and the fracture system. Drawdown will essentially continue to expand around the foot print of the mine workings and down to the lowest levels of mine excavations.

Access drifts can expand the drawdown area but they involve a relatively small amount of void space, so these areas would refill and recover relatively quickly when mining ceases. Drilling extends several hundred feet into the rock surrounding the drifts and these boreholes can dewater an area with a larger footprint during operations without creating extensive connections of fractures. The drill holes and the fracture connections that they establish can be substantially sealed by grouting. Since mining stopes are within the areas dewatered by exploration boreholes, much of the dewatering may have occurred by the time mining begins. The principal difference is that stoping permanently exposes a large surface area (thousands of square feet instead of a borehole a few inches in diameter) and establishes extensive connections between the fractures and the stope void space.

To the north, as the mine workings extend across the valley, conditions in the Wolf Camp fault, Anfo Fault and other areas show an increase in permeability in fractures. Zone 6E would extend development access workings to 27850N, 7000E, between elevations 2650 ft. down to 2100 ft. The 1997/98 studies indicate that total inflow may increase roughly fourfold if mine workings are extended down to the 2100 ft. elevation. Higher water flows may be encountered in this area, but the adjacent fractures may have limited storage and may be dewatered relatively quickly. Monitoring well LF-3 is completed between elevations 2332 ft. and 2312 ft., at coordinates 28079N, 7069E, and potentially could be dewatered by the Proposed Action or Alternative 2.

The focus on the magnitude of water flows relates to the potential for future impacts from water movement into and out of the mine (e.g., drawdown and water quality) and the ability to mitigate this movement to prevent or reduce those impacts. Grouting technology can successfully reduce fracture flow when water movement involves much greater levels. The grouting mitigation should substantially control the water flow during and after mining.

Table 3 identifies the approximate dimensions of predicted areas of drawdown for the "conservative" (Figures 12 and 13) and "expected" scenarios (Figures 14 and 15) from the hydrology model.

Table 3. GROUNDWATER DRAWDOWN AREA APPROXIMATE SIZE AND DEPTH

	DURING MINING*	AFTER MINING*
Actual To Date	700-1000 ft. wide 3200 ft. long 600 ft. deep	——— ——— ———
Predicted "Expected Case"	2800 ft. wide 4600 ft. long 350+ ft. deep	1800 ft. wide 4000 ft. long. 400 ft. deep
Predicted "Conservative Case"	3000 ft. wide 4900 ft. long 350+ ft. deep	1800 ft. wide 3800 ft. long 400+ ft. deep

*Approximate largest dimensions of an irregular drawdown area around the mine.

The hydrology "model used for computation of flows and impacts was constructed using the known topography, geology, and meteorology of the area, including the two principal fault systems (the Wolf Camp fault and the Curlew Fault), the known hydraulic conductivity of the different materials, and the heads measured in site and regional wells. Where there was uncertainty in any of the inputs, the values which would produce the maximum mine inflow and head impact were chosen from the measured ranges. The initial conditions predicted by the model have been calibrated against the observed water levels in the wells, by adjustment of hydraulic parameters of materials within their ranges. The model was then subjected to the hydrologic stresses imposed by mining, and the inflow and head response to mining was predicted.(29)"

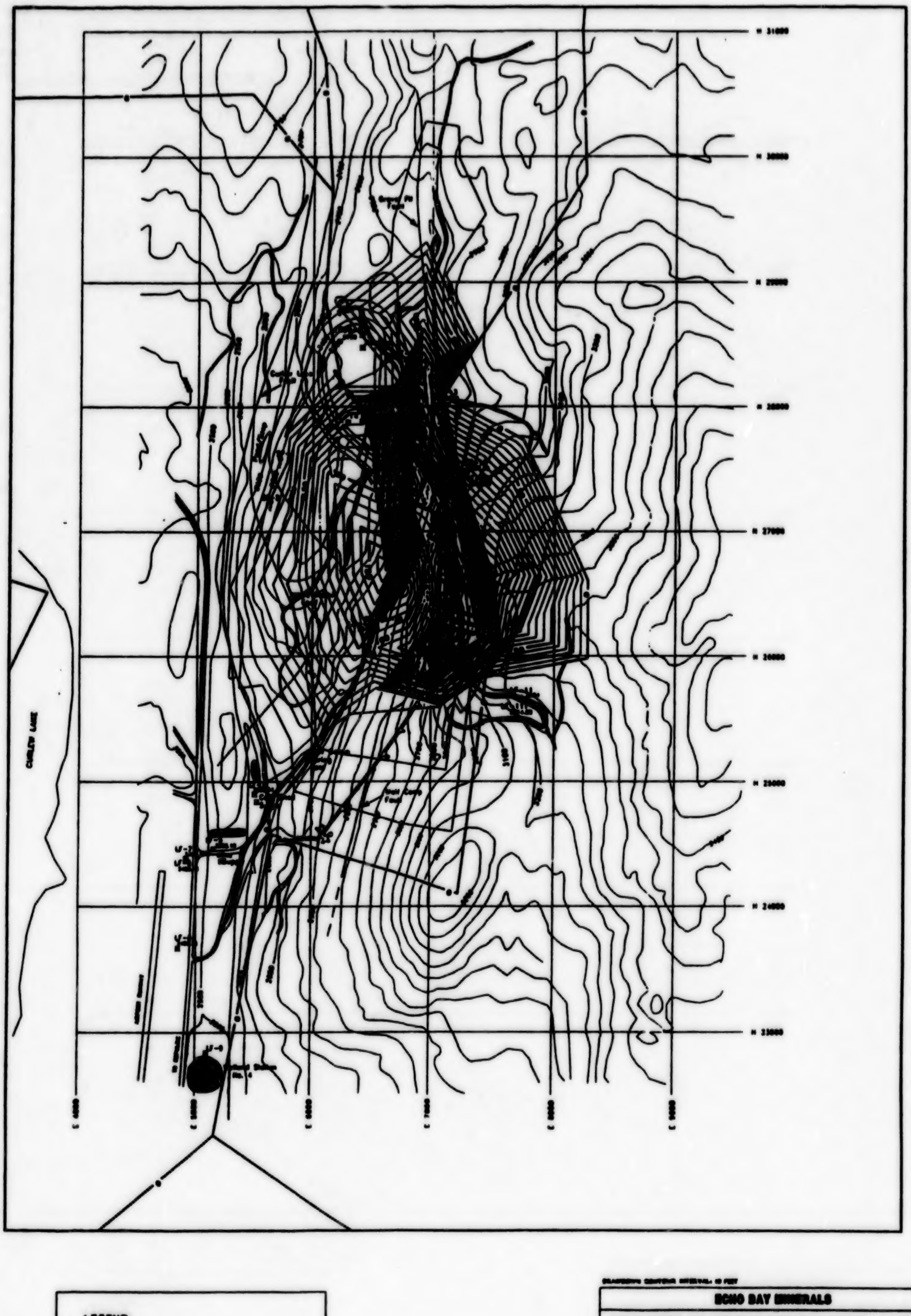


Figure 12. DRAWDOWN AREA DURING MINING - CONSERVATIVE SCENARIO. Illustrates predicted area and depth of drawdown of groundwater around Proposed Action using BLM criteria.

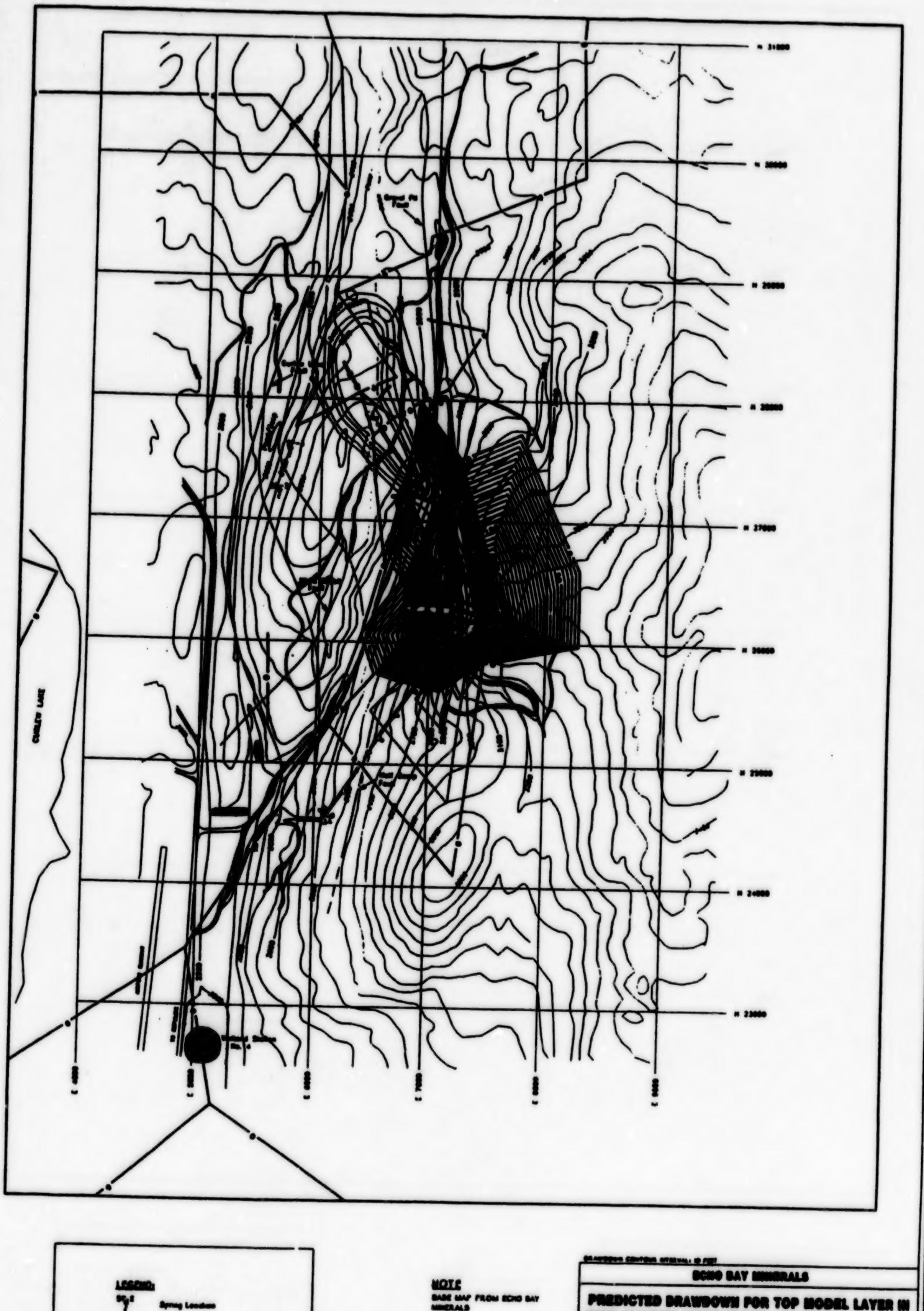


Figure 13. DRAWDOWN AREA AFTER MINING - CONSERVATIVE SCENARIO. Illustrates predicted area and depth of drawdown of groundwater around Proposed Action using BLM model criteria.

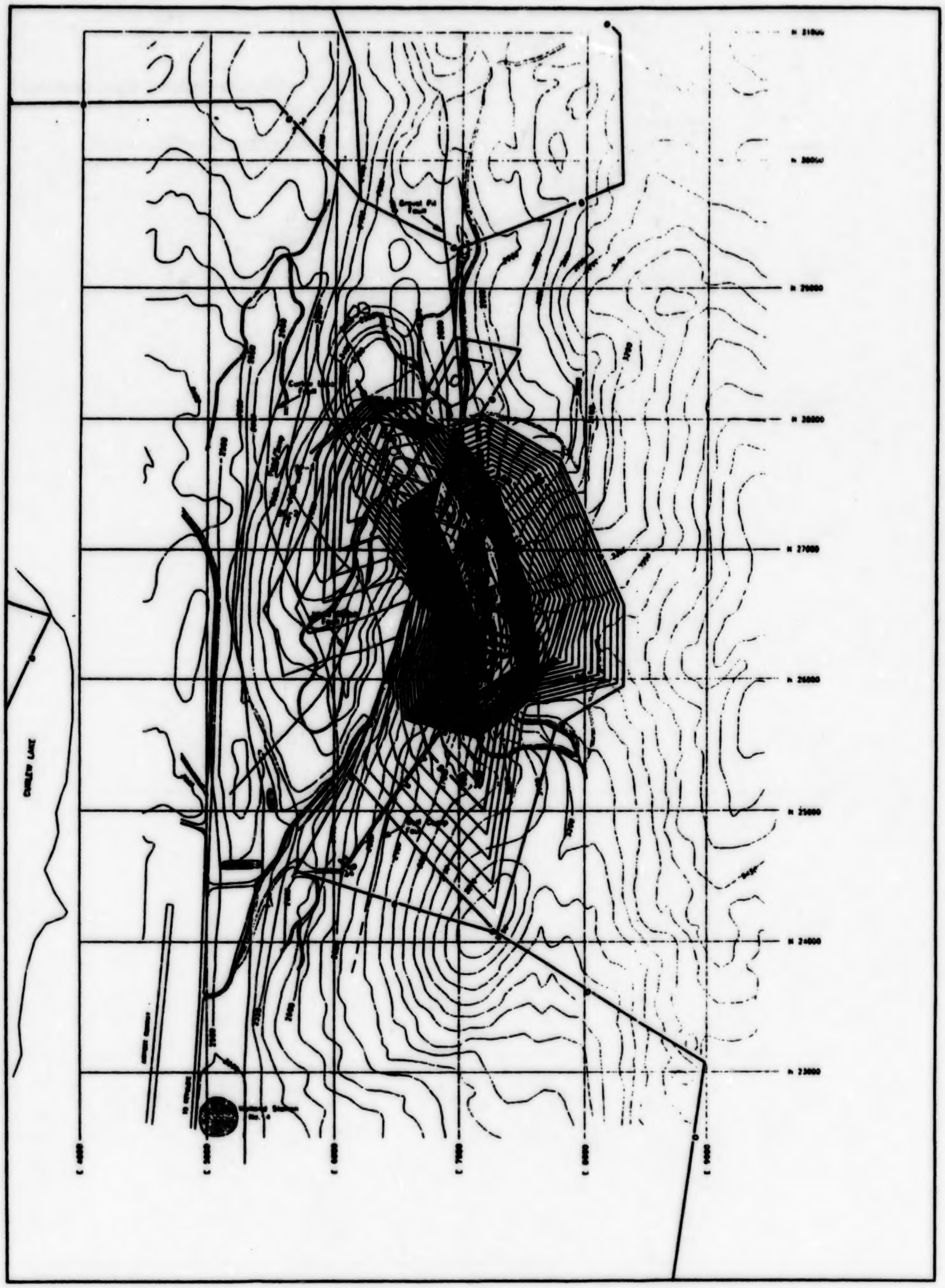


Figure 14. DRAWDOWN AREA DURING MINING - "EXPECTED" SCENARIO. Illustrates predicted area and drawdown depth of groundwater around Proposed Action using EBM model criteria.

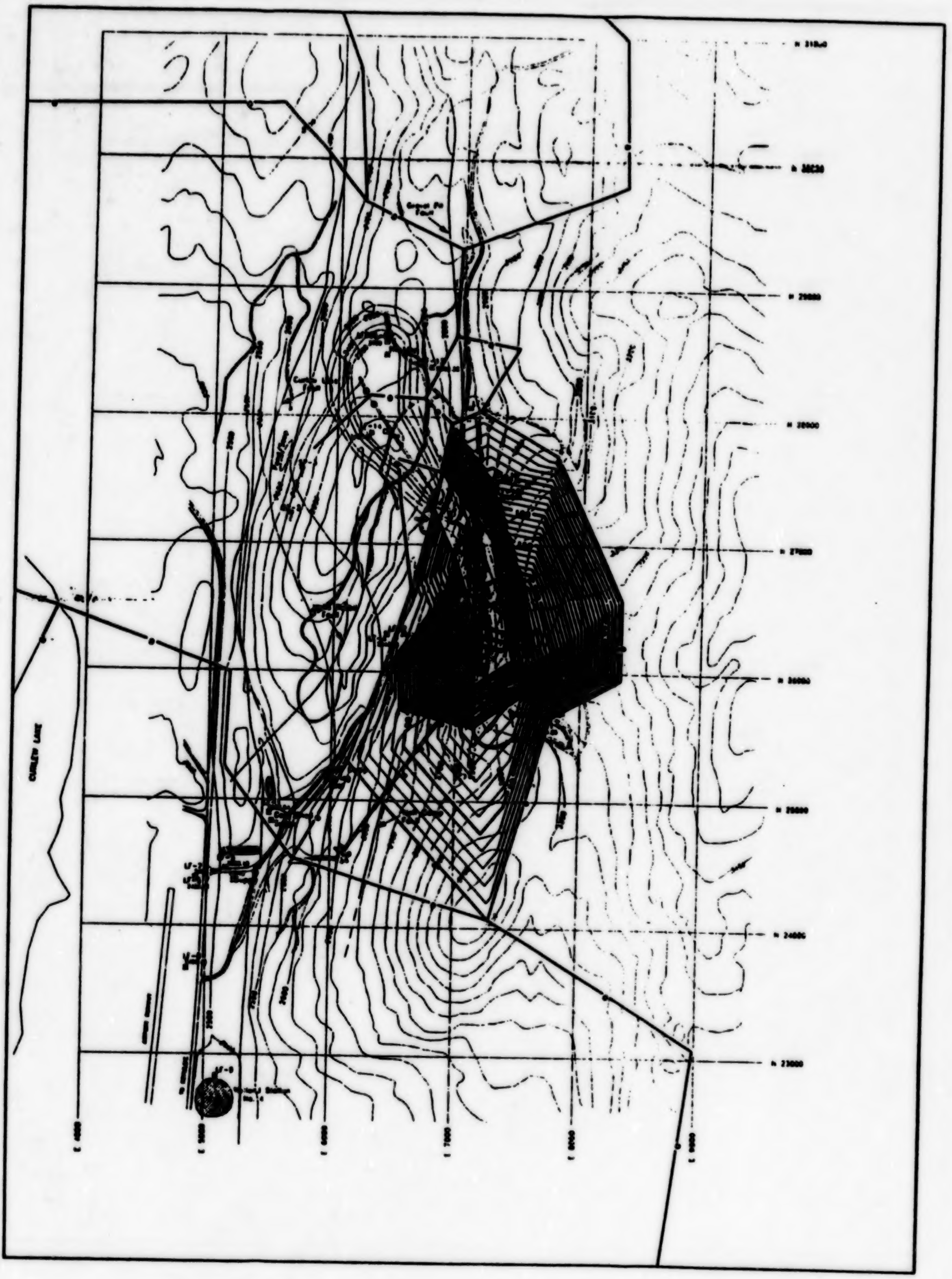

CURLEW LAKE
LEGEND:
LF-5
Well Location
2500
Water Level Elevation (March, 1996)
SP-2
Spring Location
Fault
Predicted Drawdown
Wetland
NOTE
BASE MAP FROM
ECHO BAY MINERALS
DRAWDOWN CONTOUR INTERVAL - 10 FEET
ECHO BAY MINERALS
PREDICTED DRAWDOWN FOR TOP MODEL LAYER IN
MINE VICINITY AFTER MINING, EXPECTED CASE

Figure 15. DRAWDOWN AREA AFTER MINING - "EXPECTED" SCENARIO. Illustrates predicted area and drawdown depth of groundwater around Proposed Action using EBM criteria.

The subsidence analysis indicated that net effect may of increased void space in the crown pillar may be sufficient to allow all mine inflow to exit through the crown pillar regardless of the specific amount of inflow predicted. The hydrology model addressed this by assigning "infinite" permeability to the crown pillar although the actual effects will depend on whether the fractures connect extensively through the crown pillar.

Based on the parameters used, location of features and the hydraulic conductivities, the hydrology model predicted that outflow would be via the Wolf Camp and Gravel Pit faults and would move down Wolf Camp valley.

The potential for some drawdown impacts to wetlands exists but such impacts are not predicted. The "conservative" scenario shows that the potential drawdown area may extend partially beneath the northern wetland (#1) and almost to the southern wetland (#2) by the end of mining. This does not occur in the "expected" scenario.

However, impacts could occur to the southern wetland if more of the water flowing across the drawdown area seeps in as recharge and reduces the surface flow to the southern wetlands. As noted in the FEISS (p. 4-3), if drawdown depletes the amount of groundwater in storage within the saturated alluvium and fractured bedrock, the spring flow that replenishes the southern wetlands may be reduced. Since the base flow rate at Wolf Camp spring ranges as low as about 1 to 3 gpm for several months a year, it may not take a substantial amount of increased infiltration into the valley over the drawdown area to reduce the spring flow.

The southern wetlands can probably be maintained by surface and groundwater flow from the adjacent drainage to the west. With both the northern (#1) and southern (#2) wetlands, impacts are not predicted because the wetlands have near-surface water storage capacity that can be replenished by precipitation and overland flow. If impacts occur, it would be in the form of reduced amounts of surface water that might temporarily influence the vegetation types. After the mine refills, water to wetlands would be restored to pre-mining levels (see Sections 6.3 and 6.11).

6.2.1.2 GROUNDWATER MOVEMENT

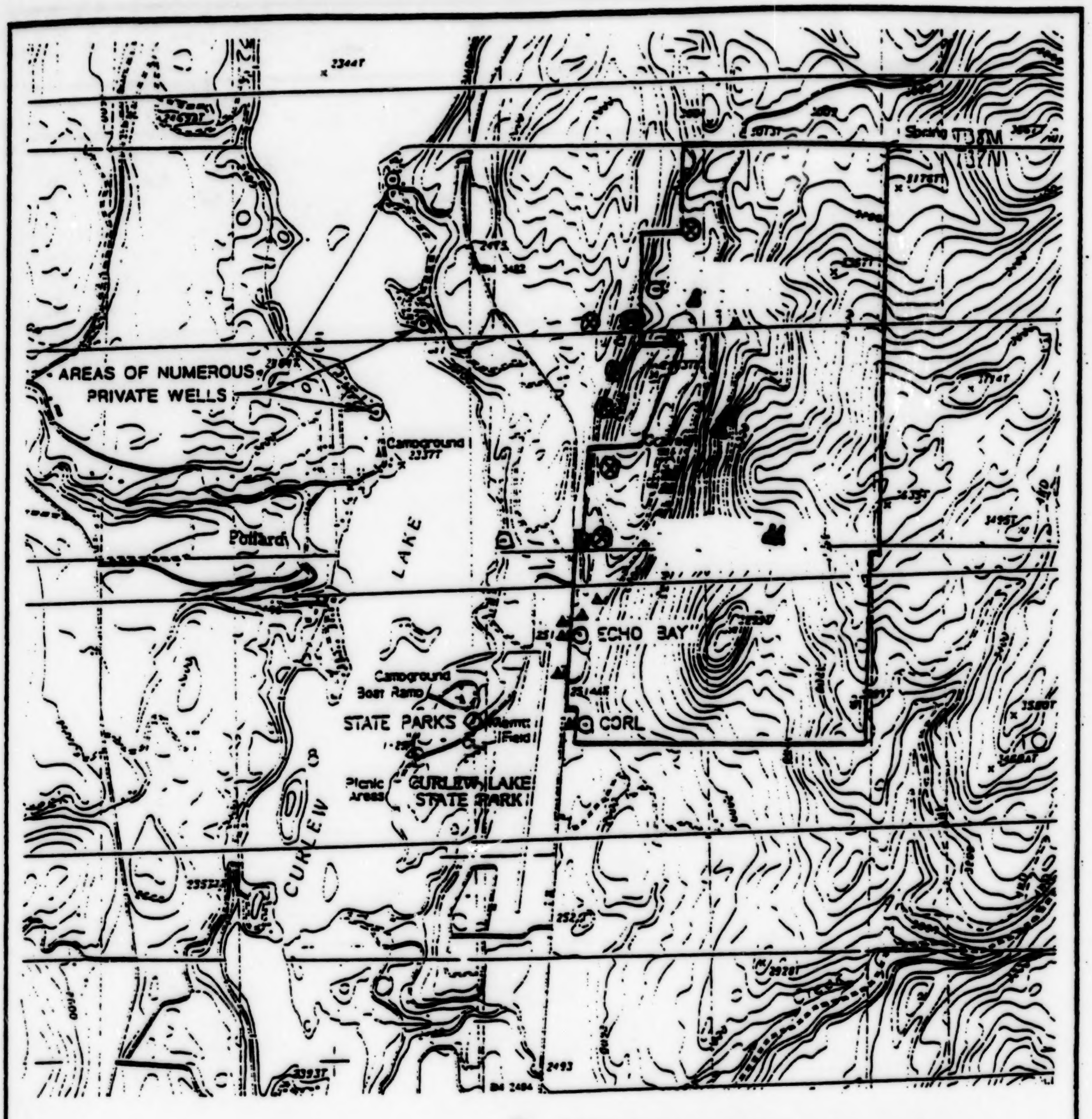
Regional groundwater movement is generally westward toward Curlew Lake as identified in the FEISS. Pre-mining zonation of water quality in the vicinity of the ore body mineralization suggests that there was relatively limited movement of water before elevated concentrations were diluted by regional flows. Monitoring has not identified any specific preferential pathways, but the data suggest that the Wolf Camp/Gravel Pit faults might function as preferential pathways where hydraulic conductivity is locally greater.

The mine workings involve thousands of feet of new large open voids and these voids connect many faults and fractures that were discontinuous prior to mining. After refilling, groundwater flow within the mine will be controlled by the mine voids and the hydrostatic head in the mine pool. Seepage to the surface/near-surface may result where mine workings intersect with faults and fractures. The 1997/98 model predicts that water may move out of the mine through the Wolf Camp fault and into the valley. From there, water would travel downgradient about 2300 feet through the alluvium to Curlew Lake.

Figure 16 illustrates the locations of most existing groundwater monitoring wells and new locations of possible stations being considered for the monitoring system (springs, piezometers and wells). The figure also illustrates the location of the project area relative to Curlew lake and some of the domestic and community water wells around the lake shore.

6.2.1.3 GROUTING - CONTROL OF INFLOW AND OUTFLOW

Boreholes and larger fractures provide at least



⊗ Approximate locations of possible new monitor stations (wells/piezometers/spring)

WELLS WITHIN 1/2 MILE OF PROJECT AREA

⊙ WATER WELL ON FILE WITH WASHINGTON D.O.E. LOCATION TO NEAREST 1/4 SECTION AS INDICATED ON WELL LOG.

▲ ECHO BAY MONITORING WELL

ECHO BAY LAMEFOOT PROJECT

SOURCE: ECHO BAY 1994

ECHO BAY MINERAL CO.
LAMEFOOT MINE
KETTLE RIVER OPERATIONS
REPUBLIC, WASHINGTON

Figure 16. WATER RESOURCES INVENTORY MAP - Illustrates existing monitoring wells, proposed monitoring wells & springs, and general location of the project area relative to Curlew Lake and private water wells.

seven potential connection pathways for water to leave the mine workings including,

1) boreholes from the surface penetrating directly into the mine workings,

2) boreholes from the surface penetrating fractures that intersect with mine workings,

3) boreholes from underground penetrating fractures that intersect with the surface/near surface,

4) boreholes from both the surface and underground penetrating the same fracture underground forming a through-connection,

5) fractures that connect continuously through the crown pillar from the underground workings to the surface, particularly where the crown pillar is relatively thin (60-100 feet wide),

6) larger faults and fracture zones, such as the Wolf Camp and Gravel Pit faults, and

7) diffuse permeability through smaller interconnecting fractures extending through the crown pillar to Wolf Camp valley.

Figures 17, 18 and 19 illustrate the relation between underground mine workings, boreholes and the surface.

If boreholes and fractures are grouted as planned, it should be possible to almost eliminate water movement along the boreholes. With the permeation grouting to seal fractures as required by the 11/30/94 ROD, Section IV.E, the grout should penetrate a much larger area and substantially reduce water movement, as analyzed in the FEISS(50), Sections 4.1.2.1, 4.1.6, 4.3.6 and 4.16. Grouting of fractures would penetrate deeply into the surrounding rock mass and partially reduce the water movement by up to 50% (Table 4).

The grout specified in the 11/30/94 ROD is more chemically resistant, will have greater penetration into fractures, and will be more likely to fully seal fractures; as a result, it should last longer the 1994 grouting before deteriorating under the water quality conditions predicted post-closure in the mine. Grouting should reduce the rate of outflow post-closure and increase pathway lengths, assisting the dilution and attenuation of undesirable constituents in groundwater leaving the mine.

If any ungrouted holes establish connections to the surface directly or through fractures, and seepage to the surface occurs after mine refilling, it may be necessary to drill from the surface to perform corrective grouting to reduce outflows as noted in the FEISS, Section 4.16.1. If the seeps develop from holes that were originally drilled from the surface, corrective grouting could take place from former drill pads. However, if seepage is associated with holes drilled from underground or some other type of connection, surface access may be difficult or infeasible. If seepage to the subsurface is detected by the monitor wells in the valley, successful corrective grouting might be difficult or impossible to achieve if the source location cannot be determined.

Where open holes are identified, they will be plugged in accordance with the plan of operations. Grouting operations are proceeding now to seal underground boreholes and fractures that are currently accessible.

The crown pillar above much of the mine is relatively thin, and may be as little as 40-50 feet wide in places. The inclined crown pillar is typically about 60 to 100 feet thick along its thinnest dimension (perpendicular to the surface) over a 1500 foot length from Wolf Camp valley southward, and is generally no more than about 250 feet thick, as measured horizontally from the mine workings to the surface. From Wolf Camp valley northward, the crown pillar thickens considerably and may be several hundred feet thick where the mine workings are deeper underground.

Surface inspections and evaluation of monitoring data at the time of refilling would be needed to determine whether there is groundwater outflow and/or surface discharge. If needed, corrective measures would be developed. Water quality within the mine is predicted to degrade as over time so the quality

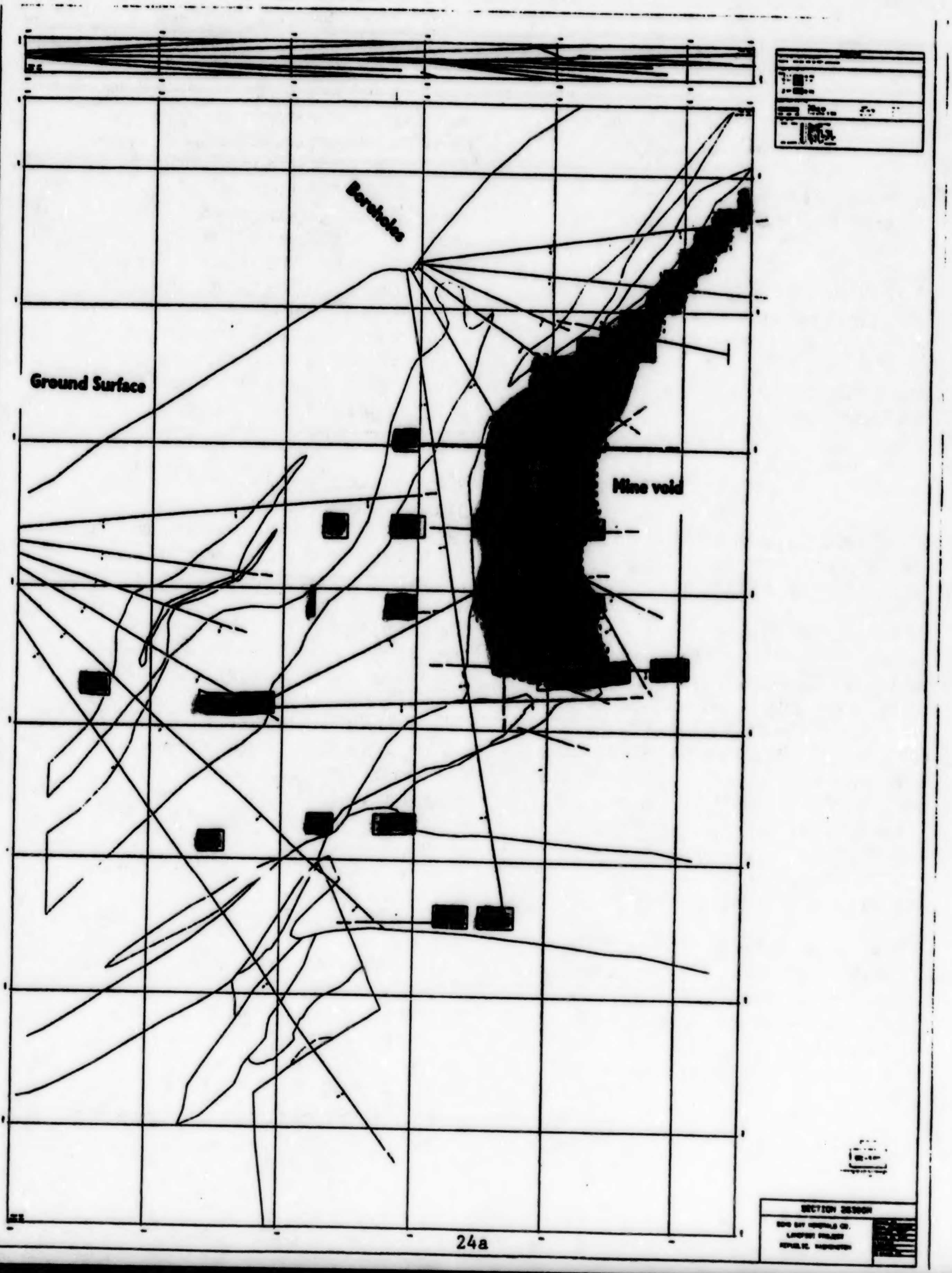


Figure 17. POTENTIAL DISCHARGE SOURCES. View north on cross-section at 26300N. Illustrates relationship of mine workings to boreholes (straight lines) and the ground surface above Wolf Camp valley.

Figure 18. POTENTIAL DISCHARGE SOURCES. View north on cross-section at 27300N. Illustrates relationship of mine workings to boreholes and the ground surface above Wolf Camp valley.

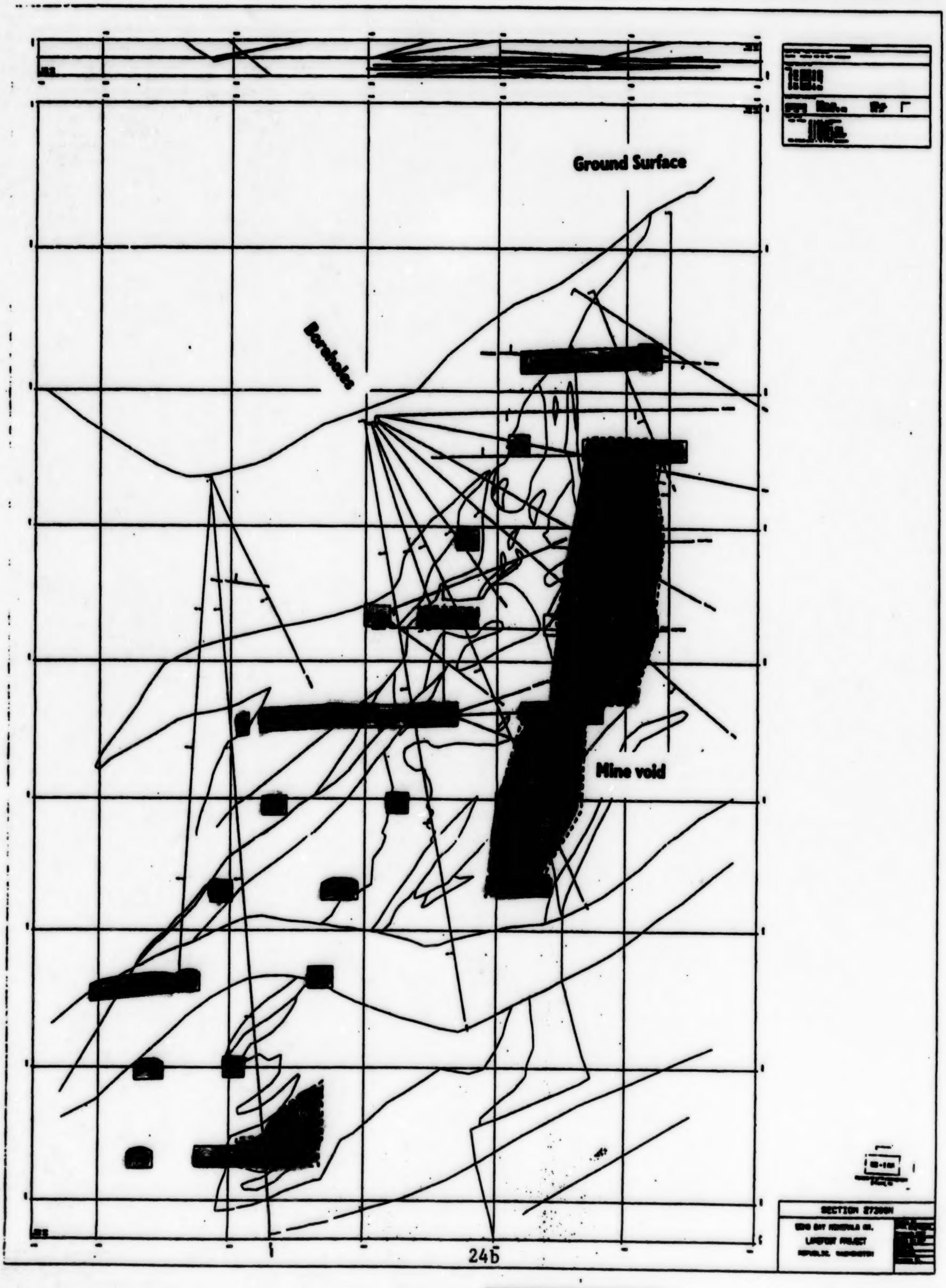
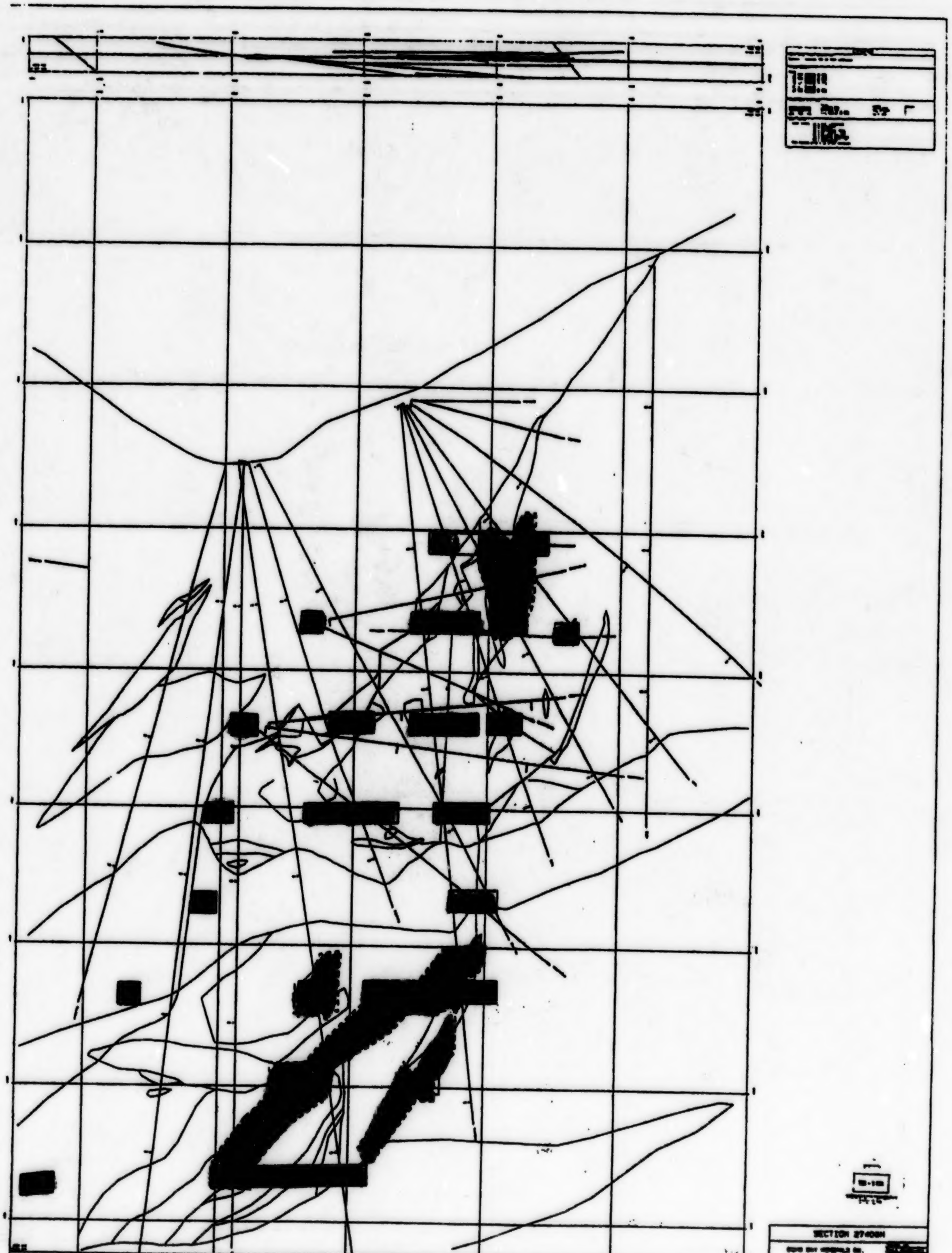


Figure 19. POTENTIAL DISCHARGE SOURCES. View north on cross-section at 27400N. Illustrates relationship of mine workings to boreholes and the ground surface above Wolf Camp valley.



of any discharges would decline. If seepage to the surface or near-surface occurs and other corrective measures are unsuccessful, water treatment may become necessary, as described in the FEISS, the 11/30/94 ROD, and the plan of operations.

Table 4. Observed & Predicted Groundwater Inflows Without (W/O) and With (W) the Predicted Influence of Grouting Boreholes and Fractures

	Before Mining	During Mining		After Mining	
		W/O	W*	W/O	W
FEISS		124	64	22	11
9/20/95 EA**			10		10
"Conservative"	3	115	58	26	13
"Expected"	3	46	23	13	6.5
Observed***			18		<18

*Inflow reduced 50% by grouting all points of inflow(50) >1gpm per FEISS Table 4.1-1 and 11/30/94 ROD

**Before the 2750 Study was conducted, some grouting had taken place on most levels in existence at that time.

***Includes estimated 1 to 2 gpm of moisture lost to evaporation due to ventilation system

6.2.1.4 MINE REFILLING

New information obtained from the 1997/98 studies of North Lamefoot indicate that upon termination of operations, the Lamefoot Mine may only partially fill with water to the level of the Wolf Camp valley (2750 ft. elevation) or slightly higher. Overall rates of inflow during and after operations will be less than FEISS predictions, but may be several times greater than predicted in 1995.

The FEISS predicted over a tenfold increase in inflow from groundwater if mining progressed to the 2200 foot elevation, primarily due to the increased surface area that would be exposed and mining into the saturated zone.

The hydrological model examined the existing mine inflow rates and potential inflow rates that might occur from interception of fractures with the hydraulic conductivity values encountered at the Wolf Camp fault north of the present stoping areas. A sensitivity analysis also examined possible values for recharge due to infiltration of precipitation. The "conservative" and "expected scenario inflow values represent the reasonably foreseeable range of inflow that might be predicted from the data, and actual values may fall within this range.

There are several possibilities that may effect refilling. Overall rates of inflow during and after operations will be similar to or less than the FEISS. The water may exit as seeps to the surface, or it may pass to the valley alluvium through the subsurface through voids in the crown pillar. The result may be that the mine may be unable to fill higher than the level of Wolf Camp valley.

The scenario predicted in the hydrology model for the refilling projections is that the mine may fill to the level of the valley and then all water may exit through the crown pillar along Wolf Camp fault and then travel southwest through alluvium down the valley and then westward to Curlew Lake. The pathway distance modeled was about 2350 ft. Seepage via faults, crown pillar fractures, or ungrouted boreholes would follow a similar route to Curlew Lake. This pathway is similar to the one analyzed in the FEISS (Sect. 4.1).

Based on the 1997/98 studies, post-closure inflows during refilling might range as high as 46 to 115 gpm for inflow until water levels within the mine reach the valley level. Above the valley level, the rate of inflow is projected decrease substantially. Partial refilling to the valley level may be achieved in 20 years at the current average inflow rate of 18 gpm. **Table 5** shows approximate filling rates for the "conservative" and "expected" scenarios which could be as rapid as five to eleven years.

Another possibility for post-closure outflow would be a scenario where there is less permeability increase in the crown pillar and less near surface permeability in the Gravel

Pit/Wolf Camp faults. The 1995 studies modeled a similar scenario without identifying higher downgradient permeability on a fault (Wolf Camp/Gravel pit faults) that might create the potential for a preferential pathway. Grouting that took place in 1994 or earlier probably reduced the mine inflow for the mine workings that were examined for the 2750 Study, and those lower inflow rates influenced the 1995 predictions about inflow during mine refilling Wolf Camp valley.

Under the 1995 model scenario, the mine refilled almost completely and the model identified that outflow water moved slowly westward along the regional gradient with localized deviations along faults and fractures instead of more rapid movement down a preferential pathway along Wolf Camp valley. Specific pathways were not identified, so approximate straight-line westward distances are examined for the EA. Water might move generally west-southwest about 1800 ft. toward the nearest residence and a westward a total of about 3200 ft. to Curlew Lake and the resorts.

Filling estimates are made to identify the approximate time involved before the mine water reaches the level of Wolf Camp valley. At that point, potential sources of surface seepage may start to become evident and corrective mitigation would begin, if necessary. If the mine cannot refill above this level, the crown pillar would remain exposed and water quality within the mine workings would continue to decline.

After water in the mine rises above the level of Wolf Camp valley, the potential for outflow to the valley increases because the crown pillar can be relatively thin (60-100 ft.) along much of its length, the possibility of fully penetrating fractures increases, and water in the fractures becomes subject to the head in the open mine workings. The higher mine fills above valley level, the greater the head on the water within the mine workings and the greater the possibility that localized outflow may occur along a borehole connection or along a fracture through a thin part of the crown pillar. Also, above the valley level, more boreholes penetrate the crown pillar from the surface and underground, so there are increasing possibilities for connections to the mine void. If the outflow is not great enough to prevent refilling, the approximate filling time to the 3200 ft. elevation shown in **Table 5** would be amount of time the crown pillar may remain exposed to oxidation of sulfides.

TABLE 5. APPROXIMATE TIME NEEDED TO REFILL*

RATE OF WATER INFLOW UP TO VALLEY (GPM)**	YEARS TO FILL TO VALLEY LEVEL	YEARS FOR COMPLETE FILLING TO 3200 FT. ELEV. (rate slows above valley)
18	28	50 (at 18 gpm)
23	22	75 (at 6.5 gpm)
46	11	42 (at 13 gpm)
58	9	40 (at 13 gpm)
115	5 or less	20 (at 26 gpm)

*Order of magnitude estimate for comparison purposes only. Rate will vary depending on the amount of void space and rate of inflow at different levels of the mine.

**18 gpm up to valley level and up to 3200 ft. elev.
26 gpm up to valley level; then 13 gpm to 3200 ft. elev.
46 gpm up to valley level, then 23 gpm up to 3200 ft. elev. ("expected" scenario)
115 gpm curve up to valley level, then 26 gpm up to 3200 ft. elev. ("conservative" scenario)

Hydraulic conductivity and mine inflow are difficult to predict with precision on a mine-wide scale. Hydraulic conductivities calculated in 1995 were at the low end of the typical range of values for fractured rock, so longer fill times were considered unlikely to occur naturally. The 1997/98 data indicates that the mine will likely refill faster, particularly the portion below the Wolf Camp valley.

The FEISS identified that the mine might partially refill from the 2200 foot elevation to a final elevation of 2750 feet (approx. Wolf Camp valley level) in about 2.4 years at inflow rates ranging up to about 64 gpm after grouting. The 2750 report in 1995 predicted that the mine void might completely refill in about 50 years mine void at a rate of about 10 gpm. The model in 1998 evaluates the effect of outflow through the crown pillar, boreholes and other outflow pathways that might prevent complete refilling of the mine void.

Depending on the filling rate used, the 1998 models indicate that the mine void might partially refill to the valley level in as little as 5 years or take as much as 20 to 28 years at the current mine size and observed inflow rates of about 18 gpm. Modeled rates for the expansion consider inflows ranging from 46 to 115 gpm, so if actual inflow rates approach this amount, refilling to the Wolf Camp valley level could occur in less than ten years.

If the mine void only partially refills, the crown pillar would remain perpetually unsaturated and exposed to oxidation as analyzed in the FEISS (Sect. 4.0). Sulfides along fractures and exposed rock surfaces would continue to oxidize, contributing acidity to groundwater. Over time, the sulfides would become oxidized similar to those found in the Old Timer's Adit, although more acidity might be released because the crown pillar and mine walls would be exposed to more moisture than was present in the Old Timer's Adit.

6.2.1.5 GROUNDWATER QUALITY

Monitor wells located downgradient from the infiltration discharge pond and waste dumps continue to detect elevated levels of nitrates as described in the FEISS (Sect. 3.1; p. 3.3). The nitrate levels declined after the mine operation ceased discharging water in 1994 to the infiltration pond and began hauling the water for off-site disposal at the mill.

In the spring of 1997, the Washington Department of Ecology authorized EBM to resume discharge to the infiltration pond. Monitoring subsequently indicated that nitrates had increased in groundwater near the ore and waste pads to levels that exceeded Washington discharge standards at the project area boundary(31). Monitoring data suggested that this groundwater may be gradually moving offsite toward Curlew Lake.

In accordance with the 11/30/94 ROD, Section IV.E, BLM requested EBM to coordinate with the Department of Ecology to take action to investigate further, identify the source of the elevated nitrates, and propose corrective measures if needed. EBM is conducting that investigation. At the present time, it appears that there are slight offsite impacts to groundwater in the alluvium due to elevated levels of nitrates.

The 1997/98 monitoring review also identified possible naturally elevated antimony in background groundwater at one location at the northern end of the mine workings, north of the limits of the proposed expansion area. Neither the Proposed Action nor the Alternatives involve mining expansions into that area, so no impacts are anticipated.

The neutralization capacity required by the ROD in the backfill and the naturally occurring neutralization capacity in portions of the wall rock will act to limit the amount of other constituents that dissolve in the mine water. The 1995 studies identified that concentrations of a number of dissolved constituents would likely increase within the mine pool, consistent with the formation of neutralized acid generation, in a manner similar to that described in the FEISS (Appendix A). The past predictions include high levels of dissolved constituents such as zinc, copper, sulfate, arsenic, selenium, and molybdenum. Further geochemical modeling in 1998 identified that the primary dissolved constituents of concern would be copper, zinc, cadmium, arsenic, sulfate, and manganese. These are subject to both chemical and physical attenuation (dilution) as water gradually moves out through the bedrock.

After closure and refilling of the mine, the discharges of mine waters could exceed (i.e., fail) secondary Washington groundwater quality standards for sulfate and manganese if there is a direct discharge of mine water into Wolf Camp valley (e.g., ungrouted borehole), even after dilution at Wolf Camp spring. Table 6 compares 1997/98 predictions with 1995 predictions. The sulfate and manganese concentrations predicted by the 1997/98 geochemical model are similar to those predicted by the 1995 geochemical model. Manganese may be further removed as the water passes through the southern wetlands, but sulfate concentrations would probably not be substantially altered.

However, if grouting is performed as required, mine water outflow through faults and fractures under all scenarios would be slower and more diffuse, and the outflow rate would be less than the amount modeled under the "expected" and "conservative" scenarios. Since the outflow rate would be less, dilution would be more effective in reducing the concentrations as illustrated in Table 4.

TABLE 6. PREDICTED CONCENTRATIONS OF WATER QUALITY CONSTITUENTS IN MINE BEFORE ATTENUATION

PARAMETER	1995 MODEL PREDICTION		1998 MODEL PREDICTION	
Concentrations:	Low mg/l	High mg/l	Low mg/l	High mg/l
SULFATE	1441	2560	1786	2207
MANGANESE	1.1	3.0	1.16	2.5
CADMIUM	0.003	0.005	0.0004	0.0060
COPPER	0.282	0.570	0.0001	0.0086
ZINC	1.137	1.600	0.0051	0.0420

Groundwater quality in the mine is predicted to decline gradually over time (FEISS, Section 4.3). so water quality may not have reached maximum long-term concentrations by the time refilling reaches the level of Wolf Camp valley. The most concentrated levels of sulfate and manganese would occur if there is a direct release of mine water to the surface through boreholes. However, at the earliest possible time of discharge to the valley, concentrations of these constituents may only initially be similar to the high pre-mining concentrations (e.g., a Feb. 1998 sample in the mine sump tested at >800 mg/l sulfate). Concentrations could increase over time if reactions persist above the water level in the mine.

The anticipated scenario for long term mine water quality is that concentrations of the various constituents will stabilize somewhere between the high pre-mining concentrations and the upper concentrations indicated in the model. Concentrations less that those shown in the model are anticipated because the model does not take into account the natural dilution influence from better quality background water that enters and flows through the mine.

Table 7. DISTANCE MINE WATER MOVES ALONG GROUNDWATER FLOWPATH BEFORE CHEMICALLY ATTENUATING*

	Washington State Standards	Percent Measured Attenuation	Distance (ft.)
Cadmium**	0.01 mg/l	0.4	>2350
		10	>2350
Copper**	1.0 mg/l	0.4	65
		10	3
Manganese	0.05 mg/l***	Negligible	>2350
Sulfate	250 mg/l***	Negligible	>2350
Zinc**	5.0 mg/l	0.4	1756
		10	70

*Flowpath of mine void water along 50 feet of fault and 2300 feet of alluvium from the mine to Curlew Lake. Distance greater than 2350 ft. means parameter is not completely attenuated along flowpath.

**Cadmium, copper and zinc predicted to be State primary drinking water standards within the mine.

***Secondary drinking water standard

The rocks downgradient from the mine have capacity to reduce the concentrations and/or remove dissolved constituents from the groundwater flowing along the fracture pathways (chemical attenuation). In general, the amount of attenuation is related to the amount of rock surface area contacted by the groundwater, but different dissolved constituents are attenuated to different degrees.

The actual attenuation distance is very difficult to predict because it depends on a variety of factors, such as the amount of rock that the water will pass through, the rate of water movement, the types of rock along the pathway, the extent of reactions, and the specific dissolved constituent.

The 1998 evaluation indicates that sulfate and manganese will not be substantially reduced by chemical attenuation. Copper and zinc are predicted to be within Washington drinking water standards within the mine and their concentrations would be further reduced by dilution to background levels before reaching the lake vicinity. Cadmium would not be fully attenuated by chemical means before reaching domestic wells or Curlew Lake, but the predicted concentrations are so low that these amounts would be quickly diluted to acceptable levels within a short distance after moving from the mine workings. (**Table 7**).

The 1995 studies indicated that after refilling, the limited flow through and out of the mine would likely be the same as or less than that predicted in the FEISS. In addition to chemical attenuation, the FEISS predicted that water leaving the mine would be diluted on the order of 10 times to 100 times during flow through bedrock and alluvium. **Table 8** provides some examples of how dilution might reduce the sulfate and manganese concentrations if dilution occurred as identified in the FEISS.

Actual dilution for diffuse outflow may be somewhat lower based on comparison with pre-mining zonation of natural background concentrations, as in **Table 9**, but should still be substantial.

If grouting occurs during mining as planned, outflow may instead occur in a diffuse manner either through the Wolf Camp or Gravel Pit faults as identified in the hydrological model or through fractures in the crown pillar. Under those circumstances, the slower rate of outflow would have substantial dilution as indicated in **Tables 9 and 10**. More dilution could occur if seepage through the crown pillar and faults is minimal and outflow is primarily through westward through bedrock as modeled in the 1995 studies[(4)], with more gradual dispersion.

TABLE 9 ESTIMATED DILUTION OF OUTFLOW

	Approx. Predicted Flow Rate	Degree of Dilution Without Grouting	Degree of Dilution With Grouting
Before Mining	3	50 X	----------
"Expected Case"	13	12 X	23 X
"Conservative Case"	26	6 X	12 X

The 1995 studies identified that if any unmitigated dissolved constituents from diffuse outflow through bedrock were to reach Curlew Lake, the amount of dilution at the lake would be so great that it is unlikely that the amount of water from the mine would have any measurable impact to lake water quality. The main concern would be whether dissolved constituents might impact drinking water quality at private wells for residences and resorts located between the lake and the mine.

The 1997/98 studies indicated that localized higher outflows may occur after refilling either through the crown pillar or along more permeable faults, but except for those pathways or ungrouted boreholes, the rate of movement over longer distances or for movement through bedrock may be similar to the 1995 studies. Faster movement toward offsite receptors may occur is water is released through the crown pillar or faults into the shallow alluvium in Wolf Camp valley similar to the description in the FEISS, Section 4.2.

However, with respect to sulfate and, manganese, the natural pre-mining concentrations at the mineralized zone

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DILUTION OF MINE OUTFLOW THROUGH FAULT BY MIXING WITH FLOW THROUGH ALLUVIUM - Sulfate concentrations
Dilution from Mine Workings to Property Boundary

Conc. SO4 in Alluvium (mg/l)	Flow in Alluvium Between Mine and Lake (gpm)*						
Outflow rate at highest filling level (gpm):		13.0	13.0	13.0	26.0	26.0	26.0
Mine water SO4 concentration (mg/l)		300.0	610.0	1800.0	300.0	610.0	1800.0
		Sulfate Concentrations at Property Boundary Resulting from Mixing and Dilution					
207	130	215.5	243.6	351.8	222.5	274.2	472.5
207	260	211.4	226.2	282.9	215.5	243.6	351.8
207	1300	207.9	211.0	222.8	208.8	214.9	238.2
207	2600	207.5	209.0	214.9	207.9	211.0	222.8

Water Quality Standard, Total, SO4 = 250 mg/l

DILUTION OF MINE OUTFLOW THROUGH FAULT BY MIXING WITH FLOW THROUGH ALLUVIUM - Manganese concentrations
Dilution from Mine Workings to Property Boundary

Conc. Mn in Alluvium (mg/l)	Flow in Alluvium Between Mine and Lake (gpm)*	Dilution						
Outflow rate at highest filling level (gpm):			13.0	13.0	13.0	26.0	26.0	26.0
Mine water Mn concentration (mg/l)			0.097	0.215	2.510	0.097	0.215	2.510
			Manganese Concentrations at Property Boundary Resulting from Mixing and Dilution					
0.0077	130	5-10X	0.0158	0.0265	0.2352	0.0226	0.0423	0.4248
0.0077	260	10-20X	0.0120	0.0176	0.1269	0.0158	0.0265	0.2352
0.0077	1300	50-100X	0.0086	0.0098	0.0325	0.0095	0.0118	0.0568
0.0077	2600	100-200X	0.0081	0.0087	0.0201	0.0086	0.0098	0.0325

Water Quality Standard, Total, Mn mg/l = 0.05 mg/l

Lowest concentrations for mine water quality are based on approximate pre-mine lower concentrations in the vicinity of the ore body, and might be the minimum levels possible during filling.
Mid-range concentrations for mine water quality are based on approximate pre-mine upper concentrations in the vicinity of the ore body. Actual values may fall between mid-range and highest.
Highest concentrations for mine water quality are based on approximate values generated by conservative geochemical modeling approach.
Table values are intended to illustrate the possible magnitude of concentrations at the Wolf Camp spring area, but are not intended to be a prediction of values.
Actual values will vary depending on the magnitude of release through the Wolf Camp Fault or other fractures.

Data Source: May 1998 Impact Evaluation for the Proposed Interim Expansion for the Lamefoot Mine, Schafer and Assoc., Inc. - SO4, Mn values after mining based on Table 3.3
Data Source: June 1995 2750 Level Hydrology and Hydrogeochemistry Final Report, Adrian Brown Consultants, Inc., et.al. - SO4 and Mn values LF-4, Mn values LF-10, App. B., Table 1
Data Source: June 1995 2750 Level Hydrology and Hydrogeochemistry Final Report, Adrian Brown Consultants, Inc., et.al. - SO4 values before mining, p. 3-4
Data Source: June 1995 2750 Level Hydrology and Hydrogeochemistry Final Report, Adrian Brown Consultants, Inc., et.al. - SO4 and Mn values App. B, Table 3
* Data Sources (dilution): Oct. 1994 Final Lamefoot Mine EIS, mixing rate estimated at 10:1 to 100:1 from mine workings to property boundary, p. 4-15
(Dilution of 100:1 appears high given estimate below for entire ABC model area)
May 1998 Impact Evaluation for the Proposed Interim Expansion for the Lamefoot Mine, App. B, p. 3 - model used 3000 ac. for the analysis domain in the model.
4/23/98 Memo ABC to Echo Bay, Response to Comments by BLM on Lamefoot Incremental Expansion, p. 5 (100 ac. catchment = 88 gpm avg. @ 17 in. precipitation/yr.:
therefore, 3000 ac. catchment = approx. 2640 gpm)

TABLE 8. Range of Concentrations After Dilution Exceeding State Water Quality Standards for Sulfate and Manganese for Diffuse Outflow of Mine Water through Wolf Camp Fault and fractures with No Chemical Attenuation

exceeded Washington groundwater standards and release of water of even that quality to the surface could potentially result in sulfate and manganese concentrations that are almost double or triple the Washington water quality standards after dilution at Wolf Camp spring.

Table 10 compares potential amounts of dilution for hypothetical mine water discharge rates and concentrations through an ungrouted borehole. The table identifies the relative decrease in concentrations that might be possible with simple dilution depending on amounts of mine water discharged, but is not intended to be predictive since the amount of discharge cannot be accurately predicted.

Table 10 uses mine water concentrations ranging from the natural pre-mining levels (about 300 to 610 mg/l) up to the approximate long-term high concentrations (about 1800 mg/l) that may be the probable upper limit, as noted the geochemical modeling. In most combinations, it appears that dilution alone would not be sufficient to reduce mine water concentrations from a direct borehole discharge to acceptable levels on a year-round basis. For example, using the lowest outflow rates for a direct discharge and the low pre-mining concentrations, manganese could exceed Washington groundwater quality standards for 5 months a year even with dilution.

Under the long term case in the geochemical model, Washington groundwater quality standards could be exceeded by up to 6 times for sulfate and 45 times for manganese. Therefore, if a direct borehole discharge occurs to Wolf Camp valley, it is likely that additional corrective measures will be needed to reduce the discharge or treat the water (11/30/94 ROD, Section IV.E.4.a(i) and as noted in the approved plan of operations.

Elevated concentrations of sulfate and manganese in groundwater and surface water could cause adverse impacts on recreation, resorts and domestic water supplies at Curlew Lake. Consumption of water with high levels of sulfate (e.g., above 500-600 mg/l) has a laxative effect that can cause diarrhea and associated dehydration(51, 52). The higher the concentration, the larger the percentages of people affected. Local populations usually become acclimated to higher sulfate levels, and the impact is primarily on infants, transient populations (e.g., business travelers, visitors and vacationers) and new residents. Dissolved solids such as sulfates can also cause unpalatable mineral tastes and odors (EPA, 1986). Naturally elevated sulfate at these levels is fairly common in numerous areas of the United States and is not generally considered to be a serious threat to health, but can have effects that are most noticeable to temporary visitors.

The 1995 studies and EA assumed all boreholes and larger fractures would be grouted in accordance with the 11/30/94 ROD. Based on this, the prediction was that most of the dissolved constituents would be likely to be retained within the mine pool or within the project area immediately surrounding the mine. However, some boreholes or areas may not have been grouted as planned. Given the number of boreholes, there is potential that there may be interconnections that could allow a discharge of mine water to the surface or near-surface after the mine refills.

If the mine cannot retain sufficient water to refill completely, outflow will begin either in a diffuse manner or as more direct discharges. With the past and future grouting, it may take about 5 to 28 years (or more) to refill the mine to valley level or higher before water begins flowing outward. This is intermediate between the FEISS predictions on refilling and the 1995 estimates. Additional years would be required after a discharge before any water from the mine could reach the lake or private wells. The concentration of dissolved constituents in groundwater might become elevated at the project area boundary after that the mine refills to valley level. The impacts would depend on the extent of connections through the crown pillar and the actual amount of surface discharge, if any. The monitoring program should detect any migration long before offsite

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DILUTION OF MINE WATER OUTFLOW THROUGH BOREHOLES BY MIXING WITH WOLF CAMP SPRING, SULFATE CONCENTRATIONS													
Outflow rate from borehole(s) and fractures (gpm):		6.5	6.5	6.5	13.0	13.0	13.0	20.0	20.0	20.0	26.0	26.0	26.0
Mine Water SO4 Concentration (mg/l):		300.0	610.0	1800.0	300.0	610.0	1800.0	300.0	610.0	1800.0	300.0	610.0	1800.0
Month	1997 Wolf Camp Spring flow (gpm)	Sulfate Concentrations Resulting From Mixing And Dilution											
January	2.3	232.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1657.2
February	1.8	244.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March	21.1	103.8	176.8	[illegible]	141.2	[illegible]	[illegible]	168.3	[illegible]	[illegible]	185.0	[illegible]	[illegible]
April	61.2	68.0	97.8	212.1	88.4	142.7	[illegible]	106.6	183.0	[illegible]	119.9	212.3	[illegible]
May	47.2	74.5	112.0	[illegible]	98.8	165.8	[illegible]	119.8	212.0	[illegible]	134.5	244.7	[illegible]
June	40.1	79.2	122.4	[illegible]	106.2	182.1	[illegible]	128.8	232.0	[illegible]	144.3	[illegible]	[illegible]
July	33.3	85.3	135.9	[illegible]	115.4	202.5	[illegible]	139.7	[illegible]	[illegible]	155.9	[illegible]	[illegible]
August	14.5	122.8	218.8	[illegible]	164.7	[illegible]	[illegible]	192.2	[illegible]	[illegible]	208.1	[illegible]	1171.1
September	8.9	151.7	[illegible]	[illegible]	195.7	[illegible]	[illegible]	221.0	[illegible]	[illegible]	234.6	[illegible]	[illegible]
October	4.3	197.8	[illegible]	[illegible]	236.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
November	2.3	232.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1657.2
December	1.8	244.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

WC Spring, SO4 mg/l	43.4
Water Quality Standard, Total, SO4 mg/l	[illegible]

DILUTION OF MINE OUTFLOW THROUGH BOREHOLES BY MIXING WITH WOLF CAMP SPRING, MANGANESE CONCENTRATIONS													
Outflow rate from borehole(s) and fractures (gpm):		6.5	6.5	6.5	13.0	13.0	13.0	20.0	20.0	20.0	26.0	26.0	26.0
Mine water Mn concentration (mg/l)		0.097	0.215	2.510	0.097	0.215	2.510	0.097	0.215	2.510	0.097	0.215	2.510
Month	1997 Wolf Camp Spring flow (gpm)	Manganese Concentrations Resulting From Mixing And Dilution											
January	2.3	[illegible]	0.16	1.85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.31
February	1.8	[illegible]	0.17	[illegible]	[illegible]	[illegible]	2.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.35
March	21.1	0.02	0.05	[illegible]	0.04	[illegible]	[illegible]	0.05	0.11	1.22	0.05	[illegible]	[illegible]
April	61.2	0.01	0.02	[illegible]	0.02	0.04	[illegible]	0.02	0.05	[illegible]	0.03	[illegible]	0.75
May	47.2	0.01	0.03	[illegible]	0.02	0.05	[illegible]	0.03	[illegible]	[illegible]	0.04	[illegible]	[illegible]
June	40.1	0.01	0.03	[illegible]	0.02	0.05	[illegible]	0.03	[illegible]	[illegible]	0.04	[illegible]	[illegible]
July	33.3	0.02	0.04	0.41	0.03	[illegible]	0.71	0.04	[illegible]	[illegible]	0.04	[illegible]	1.10
August	14.5	0.03	[illegible]	0.78	0.05	[illegible]	1.19	[illegible]	[illegible]	[illegible]	[illegible]	0.14	1.61
September	8.9	0.04	[illegible]	1.06	[illegible]	[illegible]	[illegible]	[illegible]	0.15	[illegible]	[illegible]	[illegible]	1.87
October	4.3	[illegible]	[illegible]	1.51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.15
November	2.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.31
December	1.8	[illegible]	0.17	[illegible]	[illegible]	[illegible]	2.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.35

WC Spring, Mn mg/l	0.0009
Water Quality Standard, Total, Mn mg/l	[illegible]

Lowest concentrations for mine water quality are based on approximate pre-mine lower concentrations in the vicinity of the ore body, and might be the minimum levels possible during filling.
Mid-range concentrations for mine water quality are based on approximate pre-mine upper concentrations in the vicinity of the ore body.
Highest concentrations for mine water quality are based on approximate values generated by conservative geochemical modeling approach.
Table values are intended to illustrate the possible magnitude of concentrations without grouting or plugging of boreholes, but are not intended to be a prediction of values.
Actual values will vary depending on the magnitude of direct release through boreholes versus more gradual seepage with attenuation if boreholes and fractures are grouted.
Dilution uses mixing of borehole discharge with typical flow from Wolf Camp spring over an annual cycle.

Data Source: May 1998 Impact Evaluation for the Proposed Interim Expansion for the Lamefoot Mine, Schafer and Assoc., Inc. -after mining, SO4, Mn values based on Table 3.3
Data Source: 4/29/97(8) Lamefoot Mine 1997 Cumulative Trend Analysis Report of Water Quality Data, EnviroData Solutions, Inc - SO4, Mn spring values for 9/22/97 .
Data Source: 1/28/98 December 1997 Lamefoot reporting data - Wolf Camp Spring Flow
Data Source: June 1995 2750 Level Hydrology and Hydrogeochemistry Final Report, Adrian Brown Consultants, Inc., et.al. - SO4 values before mining, p. 3-4
Data Source: June 1995 2750 Level Hydrology and Hydrogeochemistry Final Report, Adrian Brown Consultants, Inc., et.al. - before mining SO4 and Mn values LF-4, Mn values LF-10, App. B, Table 1

TABLE 10. Range of Concentrations After Dilution Exceeding State Water Quality Standards for Sulfate and Manganese for Direct Outflow of Mine Water through Ungrouted Boreholes with No Chemical Attenuation

impacts may occur any allow time to initiate additional corrective measures.

Overall, it appears that the existing mitigation measures and the natural conditions would minimize or prevent most impacts from offsite migration of undesirable constituents. Most impacts would only occur under scenarios that involve much more severe or extensive acid generation than is anticipated, less attenuation than appears to be present or failure to carry out mitigation measures. While unnecessary or undue degradation could occur if actual conditions prove to involve greater flows than predicted, more rapid transport for greater distances, or less attenuation, it appears that mitigation in the 11/30/94 and 9/20/95 RODs should be successful in preventing unnecessary or undue degradation for these scenarios.

The slow reactions and refilling rate will allow time to put the most appropriate corrective measures into place, if needed, as noted in the 11/30/94 ROD, Section IV.E, and the approved plan of operations. The project design includes long-term monitoring of surface and groundwater for 30 years to verify the degree of success of mitigation, with trigger limits set to initiate corrective actions based on actual conditions if unforeseen situations occur and monitoring identifies that any adverse concentrations might extend off-site. Additional monitoring wells and piezometers are proposed for addition to the monitoring network to more accurately assess the potentiometric surface, identify drawdown impacts, and to determine groundwater flow rates and water quality along potential preferential pathways. As a separate action under the monitoring program that is already required by the 11/30/94 ROD, Section IV.E.3.d, the additional monitoring stations would be added to the monitoring system (Section 6.13) based on evaluation of the historical and current hydrological data and hydrology modeling.

If adverse impacts appear to be extending offsite, the existing mitigation measures require further investigation to determine the suitable corrective actions (e.g., grouting from the surface), implementation of those actions, and if those measures are ineffective, installation of a treatment plant as analyzed in the FEISS (e.g., Sections 2.3.5, 2.4.5, 4.1, 4.2, 4.3, 4.15-4.16, and Appendix A) and required in the 11/30/94 ROD, Section IV.E and the approved Plan of Operations. This mitigation includes provisions for pumping out the mine, drawing down water levels so that groundwater flows into the mine, and perpetually treating all mine inflow water to levels that meet State water quality standards before discharge.

Although it currently appears unlikely that adversely elevated concentrations of dissolved constituents would migrate far outside the project area boundary, the design measures also include provisions for replacing private water supplies if additional corrective actions become necessary and those measures are ineffective in preventing or remediating water supply impacts between the mine and the Curlew Lake (11/30/94 ROD, Section IV.M.12.c).

During the refilling process, additional corrective measures can be evaluated if a need is indicated. At the time refill reaches valley level and potential outflow, water quality will still be adjusting but monitoring data will be able to provide a much more precise estimate of potential quality at the valley level years in advance of any outflow, allowing time for suitable corrective measures to be developed if needed. The mitigation measures will make it possible to directly measure the actual water quality in the mine workings to develop an accurate estimate of whether natural dilution alone will be sufficient to mitigate water impacts from surface discharge and diffuse outflow, or if supplemental measures (e.g., treatment) will be necessary.

If boreholes were missed during the operational grouting program, discharges may quickly become evident as the holes are reached by the level of the mine pool and corrective grouting measures (FEISS, Section 2.3.5.3, Summary, 1; 4.3) would be implemented. If corrective grouting is unsuccessful, other measures can be implemented, including treatment to prevent impacts from extending outside the project area. Due to the refilling rates, there will be ample time to monitor the refilling and water quality to apply the existing mitigation requirements from the FEISS and the 11/30/94 and 9/20/95 RODs.

6.2.2 Alternative 1 - No Action

The No Action Alternative involves completing operations authorized to date and proceeding to mine closure. Mitigated impacts to water resources are essentially the same as those identified in the FEISS, Section 4.0 and 5.0. Potential sources of mine inflow and outflow would be grouted as identified in the FEISS. The same uncertainties described in Section 6.2.1.3 about the grouting program apply to Alternative 1 and the same control measures may be needed.

The existing drawdown is shown in Figure 9 and the maximum drawdown would be similar to, but slightly less than the drawdown predicted for the "expected" and "conservative" scenarios. The mine workings would be about 100 ft. shallower (2200 ft. elevation instead of 2100 ft. elev.) and would end about 350 ft. farther south than the proposed expansion (i.e., 27500N instead of 27850N.

Since the authorized mine workings may not encounter the fractures with the highest permeability, the amount of inflow would be less than the amounts predicted by the hydrology model. The amount of inflow would be greater than predicted by the 1995 model (at least double since the 1995 prediction was 10 gpm and current inflow is about 18 gpm) but less than the predictions in the FEISS. However, there are practical limitations on use of models for predictions at this scale. Although more specific inflow numbers could be generated by the models, the level of predictive capability is realistically not precise enough to accurately refine inflow estimates for variations in inflow this small.

Under Alternative 1, refilling would be completed sooner than under the Proposed Action. Refilling would start about a year sooner. Although the mine voids would be slightly smaller in size, the inflow rate may be less than the Proposed Action so refilling may take longer. Water quality impacts for Alternative 1 would be the same as those predicted in Section 6.2.1.5.

6.2.3 Alternative 2 - Enlarged Interim Expansion

Mitigated impacts to water resources are essentially the same as those identified in the FEISS (Sections 4.0 and 5.0). Potential sources of mine inflow and outflow would be grouted as identified in the FEISS. The same uncertainties described in Section 6.2.1.3 about the grouting program apply to Alternative 1 and the same control measures may be needed.

The Proposed Action involves only access drifts at the lower elevations with exploration drilling that would extend up to several hundred feet into the surrounding rock. This would essentially dewater the same area as the mining zones identified in Alternative 2 down to the 2100 ft. elevation and north as far as the 27850 coordinates. However, because this alternative involves stoping at lower elevations, fractures would become more extensively connected with a greater possibility of water movement through the mine post-closure. If grouting is carried out in advance of stoping as required in the plan of operations and the 11/30/94 ROD, the fractures would be sealed before the area is mined, so impacts should be similar to the Proposed Action.

The existing drawdown is shown in Figure 9 and the maximum drawdown would be similar to, but slight greater than the drawdown predicted for the "expected" and "conservative" scenarios. The deepest stoping would be the same depth as the Proposed Action, but two additional exploration drifts would extend down to about the 1850 ft. elev. and associated exploration drilling would extend out to several hundred feet from those drifts.

As a result, drawdown may decline down to the elevation of the lowest drift. Since most of the impact would be due to one drift to each area and grouting would be required in accordance with the 11/30/94 ROD for fractures and boreholes, the groundwater impacts should be minimized and readily reversed as soon as exploration operations cease and the lower workings are allowed to flood. Grouting in accordance with the plan of operations in advance of the extension of exploration drifts should seal fractures that are encountered when discharges are readily identifiable and before they are dewatered by the continuing drawdown. Further hydrological analysis and environmental review would be required before any mining would be authorized in the Zone 7 and "north" North Lamefoot exploration areas.

Allowing drift and fill mining to include all seven zones about the 3070 ft. elevation should no involve any substantive differences from those identified in Section 6.2.1.1. Alternative 2 extends the mine workings to an elevation about 100 ft. higher and about 80 ft. farther to the east. However, the existing 3145 access ramp is located on the east side of the proposed mining area, so it has already caused much of the dewatering that might be expected for this vicinity. Other than crown pillar permeability increases, no higher capacity inflow/outflow areas have been identified.

Since the mine workings in Alternative 2 may encounter some fractures with the greater permeability, the amount of inflow could be similar to the amounts predicted by the hydrology model in Section 6.2.1.3.

Under Alternative 2, refilling would take slightly longer than the Proposed Action because mining would continue operations slightly longer and create more void space to fill. Refilling would start about a half year later. Water quality impacts would be the same as those predicted in Section 6.2.1.5. No significant unmitigated impacts are predicted.

6.3 SURFACE WATER

6.3.1 Proposed Action

As described in Sections 6.2.1.1 and 6.11, there is a possibility of some temporary reduction in water levels at two of the wetlands; Station 1 - the northern (#1) wetland, and Station 2 - the southern (#2) wetland.

Impacts to surface water would be similar to those analyzed in the FEISS, Section 4.2, which predicted that "surface water may be degraded due to seepage of groundwater from the backfilled mine" with "...possible increased dissolved constituents in springs or seeps that contribute to surface water in the Wolf Camp drainage." In general, these conclusions reflect the results of the 1997/98 studies, which indicate that cadmium, copper and zinc will have slightly elevated concentrations, along with higher concentrations of manganese and sulfate. Concentrations of cadmium, copper and zinc that aren't chemically attenuated will be readily diluted to acceptable levels.

The main difference between the FEISS and the 1997/98 studies is that the FEISS was premised on all grouting being fully completed, which provided a high assurance that direct outflows would be prevented. Information now indicates that direct discharges to the valley through boreholes may be more likely due to uncertainties in the extent of grouting.

Elevated concentrations of manganese and sulfate that enter the valley and travel to the southern wetland (#2) will be at least partially mitigated by the wetland. Wetlands have the capacity to partially remove both manganese and sulfate through a variety of reactions, but they mainly provide a "polishing" effect in reducing concentrations and the degree of removal(55) can be inefficient and unreliable, especially where the method depends on a natural wetland instead of a constructed wetland specifically designed for the predicted situation. However, if a discharge occurs into the valley, the wetland would provide a temporary reduction in concentration levels while the primary mitigation measures required under 11/30/94 ROD are being developed and put into place. The net result is that no significant unmitigated impacts to surface water are predicted.

6.3.2 Alternative 1 - No Action

Impacts would be similar in intensity and effect to those described in the FEISS, Section 4.0 (e.g., Sect. 4.2, 4.15, 4.16) and Section 5.0.

6.3.3 Alternative 2 - Enlarged Interim Expansion

Impacts would be similar to those described in Sections 6.2.1.1, 6.2.3, 6.3.1 and 6.11, but the drawdown would be slightly deeper and the footprint of the drawdown would be slightly larger. This drawdown should be minimized by the mitigation measures, and would be eliminated soon after the workings were allowed to flood.

6.4 GEOCHEMISTRY

6.4.1 Proposed Action

The geochemistry model was updated to analyze the water quality that might result from the increased quantity of PAG waste rock in the backfill, and the long-term exposure and oxidation of PAG rock in the crown pillar that is likely to result if there is incomplete filling of the mine. Table 1 identifies the differences between the tonnage involved in the proposed action, the 9/20/95 EA, and the FEISS. As noted in Section 3.0, the issue is the potential impact on water quality and the effectiveness of mitigation measures, rather than simply the PAG rock tonnage.

Numerous scenarios were modeled to identify possible effects on water quality resulting from various combinations of parameters, and sensitivity analyses included evaluation of upper and lower limits for inflow water quality. Finally, the analysis was revised to evaluate the effects of attenuation on reducing concentrations as water moves out of the mine post-closure and the transport distance out of the mine. This environmental analysis examined additional effects of dilution that would be expected to further reduce concentrations of dissolved constituents.

One of the critical concerns in developing the Limited Mining Alternative in the FEISS was the prediction that the mine would only fill to the 2750 foot elevations, leaving the mine walls above that elevation and the crown pillar perpetually exposed to air. In that scenario, there was potential for oxidation of sulfides to occur through much of the crown pillar and well into wall rock, increasing the potential for net acid generation. If acid-generation progressed to the point of creating extensive areas with low pH, the analysis was that these areas might form nucleating sites of low pH that could catalyze further reactions. The FEISS considered that fracturing of the crown pillar was expected to increase over time, increasing water inflow to the mine through rock containing oxidized sulfides.

The 1995 studies predicted that this scenario was not likely to occur. However, 1997 studies and subsidence modeling(16, 17, 18) indicate that rock mass displacement not only will likely cause crown pillar fractures to increase in size, but that much of this has already occurred. The increased void space of fractures may result in higher permeability and greater water inflow and outflow. The 1997 subsidence modeling indicates that water outflow through the crown pillar may result in permanent groundwater drawdown around the mine workings and exposure of the crown pillar to ongoing oxidation similar to the scenario analyzed in the FEISS.

Direct measurements in the Old Timer's Adit, which has been exposed to air for about 60 years, indicate that oxidation only extends a few millimeters into the wall rock surfaces and a few centimeters into fractures. At the other extreme, a strongly acidic seep along fractures dissolved the open void intercepted by new mine workings at the 2875 seep area in the crown pillar. While development of acid-generation is more probable the longer the mine rocks are exposed to the atmosphere and other localized acidic seeps may develop in the crown pillar, this will be a very slow process that will be counteracted by many other factors as the mine fills. Acid generation is predicted to stabilize over time to a condition resembling that in the Old Timer's Adit as near surface pyrite is oxidized and depleted.

Within the Lamefoot Mine, net acid generation from the wall rock and the crown pillar is unlikely on a mine-wide scale. Locally acidic conditions will probably be generated in the mine walls, backfill and the material immediately above the mine and increase over time but the overall condition may involve neutralized acid mine drainage. Acidic seeps may occur where there are localized imbalances between acid-forming and acid-neutralizing minerals in the wall rock or backfill. Acid generation in the mine will be slow due to the inherent neutralization capacity of the mine rocks, and self-inhibiting characteristics that slow the reactions at the microscopic level. Acidity that may be generated will be buffered by the neutralization capacity in the backfill and wall rock.

The characterization process used for the FEISS evaluated each rock unit at the smallest scale to determine the character of each material and define the portions of the material had potential for acid generation. Based on that process, the 11/30/94 ROD identified criteria for individual rock units using acid-base accounting tests of chemical composition. Individual rock types with an intrinsic NNP greater than 20 tons $CaCO_3$/Ktons and NP:AGP ratios greater than 3:1 are considered to be typically non-acid-generating in most cases. These intrinsic factors, when applied to an individual rock type, are relatively conservative.

These same factors are less conservative when applied as backfill blending criteria for a mixture of rocks with dissimilar characteristics in an attempt to replicate non-acid-generating characteristics as a control measure. Numerous other factors limit the effectiveness of this approach. Therefore, the 11/30/94 and 9/20/95 RODs use a number of criteria in combination.

About half to 60% of the total waste rock is non-acid-generating the remainder is PAG. The 9/20/95 ROD required that greater than 50% of the PAG waste rock be placed in the cemented rock pillars, where it would be mixed with highly neutralizing limestone rock and encapsulated in cement. Higher saturation of the cemented pillars will reduce the surface area exposed to oxidation and may reduce the diffusivity of oxygen through the cemented pillars; both of which should reduce acid generation, as noted in the 9/20/95 EA. The addition of cement after the materials are mixed to meet the non-acid-generating criteria will also add additional neutralizing capacity to the backfill and help in counteracting acid-generation by placing that neutralizing capacity in direct contact with exposed sulfides.

Use of potentially acid-generating waste rock in the cemented pillars under the 9/20/95 ROD is expected to be beneficial in controlling acid generation, similar to the amendment and encapsulation method in the FEISS Selected Alternative. Any loss of strength of the pillars due to deterioration from acid generation will have negligible effects on subsidence.

The remaining waste rock with acid-generating potential that is not placed in cemented pillars is mixed with the neutralizing waste rock and Corl material and placed in the loose backfill.

The predominantly neutralizing backfill that results from the blending process is placed in direct contact with wall rock, which assists in counteracting any acid generation from the wall rock and crown pillar in a manner similar to that analyzed for the Selected Alternative in the FEISS (Sections 4.1-4.3) and in the 9/20/95 EA. Those measures would be applied to the expansion areas as well. As the mine refills and acid generation occurs, any acidic waters would mix with neutralizing water in the mine pool. The water in the mine pool will provide better contact with neutralizing rock, allowing more efficient use of the neutralizing capacity of the backfill and wall rock than is possible for the rocks that are above water, and this may compensate for localized imbalances in neutralization capacity. Acid generation from the lower portions of backfill will likely decrease as those areas become submerged.

Acid-generating reactions will likely persist after refilling has reached its highest level and will likely continue until the pyrite has been oxidized in fracture surfaces in the wall rock and crown pillar. The 1997/98 studies found that the mine water would likely remain in the near-neutral range during filling and that the mitigation measures provide sufficient neutralizing capacity to accommodate greater amounts of PAG rock in the backfill in the event that current predictions underestimate the actual amounts again. The 1997/98 geochemical model used about 501,000 tons of PAG waste rock as the base case for backfill.

The geochemical model parameters were selected to test a wide range of potential conditions that might exist following mine closure. The mine will become humid and mine wall surfaces will become moist (conducive to acid-generation) when ventilation fans are removed and the mine starts to re-saturate. After the mine refills to at least valley level, some or all of the crown pillar may potentially remain exposed to oxidation in perpetuity. Backfill would be submerged at least up to the elevation of the valley. Haulage drifts will be open conduits filled with water under hydrostatic pressure connecting all of the mine workings.

Numerous models runs were made with different combinations of factors. Models tested oxidation of 10% to 75% of the pyrite. Results of 10% pyrite oxidation were used for the final model because that yielded the poorest quality water, and that water was used for subsequent model sequences. Coating of neutralizing materials by acid generation reaction products was evaluated as reducing available neutralizing potential by 50%.

The models addressed the long term exposure of PAG rock for decades or longer. While exposed, the pH of portions of the waste rock and crown pillar might gradually decline over decades as localized acid-generation consumed neutralizing potential and concentrations of sulfate and other dissolved constituents would increase. After waste and wall rock are submerged, existing oxidized rock surfaces may continue to react for some time before the reactions would decrease. To examine the long-term effects of acid generation in a perpetually exposed crown pillar, sensitivity analyses used inflow parameters ranging from the best to the poorest water quality.

The models evaluated effects over ten pore volumes of water, or the equivalent of ten sequences of refilling the mine. This would be similar to the effects over time for between about 100 to 500 years, depending on the rate of flow through the mine.

Localized acidic seeps would mix with the mine pool, come into contact with neutralizing backfill and become neutralized. The pH of the water would remain in the near-neutral range, limiting the amount of constituents in solution and minimizing impacts to water quality. Carbonate materials exposed to acidic seepage may gradually become coated with iron oxides and gypsum which could decrease the effective availability of the neutralizing materials to somewhere between 15% and 50% of the laboratory test values for NP.

Since the 1995 studies tested coating effects and identified that coated materials may have as little as 15% of the neutralizing capacity of uncoated rocks, the sensitivity analyses examined this as well. Under this and other limiting conditions, the sensitivity analyses indicated that it would take about 1.5 to 2.5 million tons of PAG rock in the backfill to consume 95% to 100%, respectively, of the available neutralizing capacity. The long residence time of the water in the mine might increase the actual neutralization capacity to at least 35% of total value and could be higher.

The amount and rate of mine filling can influence the long-term predictions for water quality. This makes prediction of the ultimate balance between acid generation and acid neutralization uncertain. The 1997/98 hydrological models indicate that complete refilling of the mine is unlikely.

Acid generation in the crown pillar would persist if the mine does not completely fill. Therefore, the 1997/98 geochemical models are based on the least amount of refilling that may occur and the greatest amount of crown pillar that might be exposed perpetually. The elevation of refilling may vary from the level of the valley to somewhat higher depending on the actual amount and location of outflow. If the mine is able to refill to higher elevations, the water quality may be slightly better.

The revised geochemical model indicates that mitigated backfill has excess neutralizing capacity and should be capable of providing long-term neutralization of acid-generating sources even if there is extensive coating of carbonate rocks by iron and gypsum.

As noted in the FEISS and the 9/20/95 EA, water quality within the mine would not be expected to substantially decline during operations but may gradually degrade over a period of decades. The reaction rates are slow to moderate and neutralization capacity should counteract acid generating reactions. However, water quality within the mine pool will probably not meet Washington groundwater standards for all constituents. Discharge of the mine waters from the project area could potentially cause unnecessary or undue degradation outside the project area due to the concentrations of mine water constituents if release is not controlled to provide adequate dilution and attenuation, especially if there is a direct discharge to the valley through an ungrouted borehole.

The degree of conservativeness of the proposed action is ultimately influenced by many other factors which, taken together, increase the assurance that the system will control acid-generation and water quality degradation. Some of these factors include the slow to moderate reaction rates of the waste and wall rock with acid-generating potential, use of the 11/30/94 and 9/20/95 ROD backfilling criteria which maintains the neutralizing capacity of the backfill and ensures thorough mixing, placement of most rock with acid-generating potential within the cemented fill, and grouting to control outflow as described in the 11/30/94 ROD and the plan of operations.

Overall, with the mitigation in the 11/30/94 and 9/20/95 RODs, the impact relative to ground water degradation resulting from mine water contamination migrating outside the mine would be similar in intensity and effect to that predicted for the Preferred Alternative in the FEISS, Section 2.4.5 (Limited Mining Development). Long-term surface and groundwater monitoring during operations and post-closure will detect if degraded water starts to migrate outside the project area, and provide time to develop corrective measures, if needed.

If other corrective measures prove to be inadequate, the 11/30/94 ROD provides for perpetual removal and treatment of all mine water. Although this option is least desirable, it will provide an effective method of preventing long-term impacts outside the project boundary and may become necessary if boreholes become seepage sites and corrective grouting is unsuccessful.

Overall, between the mitigation measures and the backfill characteristics, the Lamefoot Mine backfill should have a net neutralizing capacity sufficient to counteract acid generation from PAG rock in the backfill and sources within the crown pillar and mine wall rock. Post-closure water quality impacts would be similar in intensity and effect to those predicted in the FEISS (Sections 4.0 and 5.0).

6.4.2 Alternative 1 - No Action

Impacts would be similar in intensity and effect to those predicted in the FEISS (Sections 4.0 and 5.0), as described in Section 6.4.1.

6.4.3 Alternative 2 - Enlarged Interim Expansion

Impacts would be similar in intensity and effect to those predicted in the FEISS (Sections 4.0 and 5.0), as described in Section 6.4.1. As part of the sensitivity analyses, the geochemical models evaluated a variety of scenarios and combinations of parameters to examine the effectiveness of the mitigation measures. Among those analyzed were scenarios with up to totals of 1.5 and 2.5 million tons of PAG waste rock. In both instances, the mitigation measures were applied only to the first half million tons of PAG waste rock. Under the more extreme combinations of possible parameters (e.g., maximum coating) both scenarios consumed most of the available neutralizing potential while maintaining the predicted water quality.

Alternative 2 would apply the measures and criteria required by the 11/30/94 and 9/20/95 RODs to placement of up to 1 million tons of PAG waste rock in the backfill. The models indicate that the mitigation should provide sufficient buffering capacity to prevent acid generation and maintain water quality while providing an ample margin of safety for unexpected conditions or changes in PAG waste rock proportions or reactivity.

6.5 GEOLOGY AND SUBSIDENCE

6.5.1 Proposed Action

BLM had the Mining and Mineral Resources Laboratory, Natural Resources Canada [hereafter called CANMET] review the revised subsidence model provided by Echo Bay in 1996, and earlier models. CANMET(16, 17) determined that the type of numerical models used in 1995 and 1996 could not have identified the potential effects of subsidence on water movement through the crown pillar and were based on failure mechanisms that would not likely occur at the mine. BLM had CANMET prepare a subsidence analysis(18) that modeled the effect of rock mass displacement on fracture openings in the crown pillar to identify possible groundwater flowpaths. The model evaluated whether fractures in the crown pillar would open more or close due to movements in the crown pillar caused by mining. The model indicated that there would be a net increase in the amount of void space.

Rock stress changes as mining creates new openings, resulting in movements within the crown pillar. No slope stability issues were identified by the model under saturated conditions. There are two basic effects relevant to this analysis. As rock mass displacements occur within the crown pillar, the ground surface also may subside. Predicted subsidence is only about 0.4 to 0.8 inch at the surface, and no danger of collapse is anticipated due to the current backfilling procedures. There may be an extended time lag (decades or longer) before any detectable movement occurs at the ground surface and by that time, essentially all the displacements within the crown pillar will have already taken place. As a result, the existing subsidence monitoring system is not expected to detect any movement within the time periods identified in the FEISS and the 11/30/94 ROD.

However, displacement within the crown pillar that increases the capacity for the crown pillar to transmit water is the effect of primary concern. As rock mass displacement occurs over time, some existing fractures close, others widen, and some new fractures are created. The subsidence analysis by CANMET found that rock mass displacements are predicted to result in a net increase in the amount of void space within the crown pillar. The void space (net opening size of fractures) may increase by about 0.4 inch or more during operations and up to 0.8 inch over a period of tens of years across the footprint of the crown pillar.

The crown pillar would range in width from about 60 to 215+ feet wide in plan view, and is typically 60 to 100 feet thick along much of the 1500 ft. length down the face of the hill east of Wolf Camp valley. Some of the void spaces may extend from the mine workings to the surface either directly, through a combination of intersecting fractures and voids, or by having fractures intersect ungrouted exploration boreholes. Although the numerical increase seems small (0.4 to 0.8 inch), the net effect may be that the increase in void space could be sufficient to allow the entire projected amount of mine inflow to exit through the crown pillar, depending on the extent of interconnections and the degree that fractures fully penetrate through the crown pillar.

Most of the initial movement (60+ percent) within the crown pillar takes place within several days after underground stopes are excavated and before backfilling takes place. As a result, most of the size increase in crown pillar fractures has already occurred above the existing stopes that extend up to the crown pillar. The expansion of drift and fill mining for two levels would not result in any substantive difference beyond that which may already exist. The main effect would be the possibility of increased outflow through fractures, and mitigated impacts would be similar to those analyzed in the FEISS (Sections 4.0 and 5.0).

6.5.2 Alternative 1 - No Action

Mitigated impacts would be the same as those identified in Section 6.5.1 and in the FEISS (Sections 4.0 and 5.0).

6.5.3 Alternative 2 - Enlarged Interim Expansion

Mitigated impacts would be the similar in intensity and effect to those identified in Section 6.5.1. No slope stability issues were identified by the model under saturated conditions. The CANMET analysis and modeling described in Section 6.5.1 was for the expansion (seven drift and fill levels) of mine workings up to the 3200 ft. elevation. The potential subsidence impacts would be essentially identical to the Proposed Action.

6.6 AESTHETIC RESOURCES

6.6.1 Proposed Action

The Corl gravel pit has been developed as analyzed in the 9/20/95 EA and substituted for the Wolf Camp Quarry proposed in the FEISS. As with the original quarry, the Corl gravel pit was designed with sufficient excess capacity to accommodate potential future needs for expansions of the underground backfilling. Impacts from use of the gravel pit would remain the same as described in the 9/20/95 EA, Environmental Consequences. The pit is being concurrently reclaimed and screened from view along State Highway 21.

A limited number of new surface exploration holes and monitor wells would continue to be drilled, maintained and reclaimed throughout the life of the operations as described in the FEISS (Section 2.0). The number of new sites and the amount of associated surface disturbance will continue to decrease as the mine nears closure. Impacts are the same as those described in the FEISS and 9/20/95 EA.

6.6.2 Alternative 1 - No Action

Mitigated impacts would be essentially the same as those described in the FEISS, as modified by the 9/20/95 EA.

6.6.3 Alternative 2 - Enlarged Interim Expansion

Mitigated impacts would be essentially the same as those described in Section 6.6.1 and the FEISS, as modified by the 9/20/95 EA, with the Corl gravel pit being slightly deeper.

6.7 RECREATION

6.7.1 Proposed Action

Overall, impacts to recreation would be as described in the FEISS, Section 4.10. The main impact to recreation would be the potential change in use that could result if degraded groundwater were to reach Curlew

Lake State Park and private residences and resorts along the east shore of Curlew Lake, particularly if there is a direct discharge into Wolf Camp valley from ungrouted boreholes.

If groundwater outflow from the mine is diffuse and movement is generally westward as analyzed in the 9/20/95 EA, then areas along the east shore of Curlew Lake are within the potential pathway. Diffuse outflow through bedrock may result in sulfate concentrations increasing slightly at the property line, but pre-mining zonation of natural background water quality suggests that movement would be slow and sulfate concentrations may not progress far by this pathway.

The main water quality constituents that may cause impacts to recreation would be elevated concentrations of sulfate, manganese and dissolved solids, as described in Section 6.2.1.5. The main source of potential impacts would be if mine water leaves the mine through a faster pathway, such as through the faults (Wolf Camp or Gravel Pit faults), through crown pillar fractures, or through an ungrouted borehole. In such cases, water would follow a pathway down Wolf Camp valley, similar to that in the FEISS. Impacts would tend to be focused on the residences, community well and Curlew Lake State Park wells downgradient from the valley.

Concentrations of constituents above secondary drinking water guidelines can impart an unpalatable mineral taste and odor to water and may effect its appearance. The EPA is currently evaluating the possibility of establishing a primary drinking water standard for sulfate due to potential health-related effects. Concentrations of sulfate in excess of 500-600 mg/l can have a laxative effect that can cause diarrhea and dehydration. The larger the concentrations, the larger the percentage of people affected. Local residents can become acclimated after a few weeks, and the effects are mainly on infants, transient populations (e.g., business travelers, visitors and vacationers) and new residents. There are a number of residences and small resorts along the east shore of Curlew Lake, and Curlew Lake State Park receives tens of thousands of visitors annually.

Without mitigation, it is possible that higher concentrations of sulfate could eventually reach drinking water supplies in concentrations that could effect a large number of people since the number of recreation visitors could be in the range of 70,000 to 97,000+ (FEISS, Section 3.10). Visitors at Curlew Lake State Park and at private resorts and residences would be most likely to be effected by unmitigated impacts if sulfate and manganese concentrations substantially exceed secondary standards.

The main effect of degraded water quality could to influence perceptions of the quality of the recreation experience, as described in Section 6.2.1.5. As a result, elevated sulfate levels in groundwater that extend to drinking water supplies could potentially have indirect impacts on recreational uses. Visitor use might be reduced and at a minimum, alternate water supplies might be needed.

However, the existing plan of operations includes provisions for additional control measures to reduce outflow and discharge (e.g., additional grouting). The measures include installing a water treatment plant, if needed.

Such measures would prevent degraded groundwater in the mine from being released to a level that might effect recreation. If these measures are implemented, impacts would be as described in the FEISS, Section 4.0. It is also likely that the Washington Department of Ecology would require corrective measures to be taken if monitoring indicates that water quality impacts extend beyond the project area boundary. As a result, no significant unmitigated impacts are predicted.

6.7.2 Alternative 1 - No Action

Mitigated impacts would involve the same intensity and effect as those analyzed in Section 6.7.1 and in the FEISS (Sections 4.0 and 5.0).

6.7.3 Alternative 2 - Enlarged Interim Expansion

Mitigated impacts would involve the same intensity and effect as those analyzed in Section 6.7.1 and in the FEISS (Sections 4.0 and 5.0).

6.8 SOCIOECONOMICS

6.8.1 Proposed Action

Mitigated impacts would be essentially the same as described in the FEISS, Section 4.0. The primary effect would be to extend the beneficial impacts for the time period involved in Proposed Action.

The Proposed Action may extend the economic benefits of operations for about two months. Full production would continue until about the end of July 1999 and reduced production would continue until about September 1999.

If mitigation described in the FEISS, 9/20/95 EA and the 11/30/94 and 9/20/95 RODs is not carried out, and impacts to water resources and drinking water supplies develop and are not mitigated, a large number of people could be effected and the result could be reduced use of recreational resources as described in Section 6.7. Impacts could include reduction in the long-term economic benefits associated with Recreation due to decline in visitor use at the State Park and private resorts. However, if the measures are carried out, the long-term environmental consequences would remain the same as described in the FEISS (Table ES-1) .

6.8.2 Alternative 1 - No Action

The No Action Alternative would have the same impacts as the proposed action in the FEISS. If there were no further authorizations, operations within existing authorized areas would be completed as described in the FEISS and 9/20/95 EA. Full production mining (about 1200 tons/day) would be completed by about the end of May 1999 and reduced mining would be conducted until about July 1999 immediately prior to mine closure.

Potential drinking water quality effects to socioeconomics would be the same as described in Section 6.8.1. The same potential post-closure outflow and discharge situation exists regardless of whether or not the proposed expansion takes place.

6.8.3 - Alternative 2 - Enlarged Interim Expansion

Alternative 2 provides for extension of mine life for about 5 or more months by including all seven drift and fill levels for the expansion in Zone 2 to the 3200 ft. elevation, mining of deeper ore zone extensions within the proposed interim expansion area (essentially zones south of 27850N and above the 2100 ft. elevation), and development of exploration access to two potential new ore zones. This alternative may minimize the possibility of a disruption of ore supplies to the mill while the larger future expansion proposal (if submitted) is undergoing environmental review.

By providing for construction of exploration access, this alternative provides the ability to collect additional information on the new possible mining areas and complete the remaining studies to determine the economic and environmental feasibility of this possible larger future expansion.

This possible expansion, referred to as the "Full Mining Proposal", might extend the mine life by at least one year to May 2000. As noted in Section 1.0 (p.2), the "Full Mining Proposal" may encompass several possible areas, including Alternative 2, potential mining of all of Zone 7, potential mining of "north" North Lamefoot, and other exploration.

Potential drinking water quality effects to socioeconomics from Alternative 2 would be the same as described in Section 6.8.1. The potential for unmitigated post-closure drinking water quality impacts would be postponed for the time period in this alternative, but would otherwise remain essentially identical.

6.9 SOILS AND RECLAMATION POTENTIAL

6.9.1 Proposed Action

Mitigated impacts relative to soil and reclamation would involve the same intensity and effect as those analyzed in the FEISS Sections 4.0 (e.g., 4.7, 4.15, 4.16) and 5.0 (e.g., 5.7), as modified in the 9/20/95 EA.

Surface disturbance under the Proposed Action would be limited to surface exploration drilling with access roads and drill pads as necessary, in a manner consistent with the FEISS, 11/30/94 and 9/20/95 RODs, and the approved plan of operations.

Installation of new monitoring stations for the life of the monitoring program (30+ years post-closures) was analyzed in the FEISS and authorized in the 11/30/94 ROD, and the new stations described in this EA would be installed under that authorization even if the Proposed Action is not approved. Only one of the new stations is directly related to the Proposed Action (i.e., the northernmost piezometer).

6.9.2 Alternative 1 - No Action

Mitigated impacts would be essentially the same as those described in Section 6.9.1 and in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA.

6.9.3 Alternative 2 - Enlarged Interim Expansion

Mitigated impacts would be essentially the same as those described in Section 6.9.1 and in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA.

6.10 CULTURAL RESOURCES

6.10.1 Proposed Action

Mitigated impacts would be essentially the same as those described in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA. The Proposed Action will not affect significant historical resources and no Traditional Cultural Properties or sacred sites are known to occur at this location.

6.10.2 Alternative 1 - No Action

The analysis of impacts is the same as that described in Section 6.10.1 and in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA.

6.10.3 Alternative 2 - Enlarged Interim Expansion

The analysis of impacts is the same as that described in Section 6.10.1 and in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA.

6.11 VEGETATION

6.11.1 Proposed Action

Overall, the impacts are similar in intensity and effect to those described in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA, Environmental Consequences. Specific hydrological studies and modeling have refined evaluations of potential impacts, and these results are described below. A summary of groundwater drawdown is presented in Sections 6.2.1.1 and 6.3.

Under the "conservative" modeled scenario, groundwater drawdown extends partially under the northern wetland (#1). However, it is not certain that impacts would occur even if the drawdown area extends underneath the wetlands because of other factors. A second wetland (#2) at the south end of Wolf Camp valley might also be influenced if drawdown results in reduce flow from Wolf Camp spring. Since Wolf Camp spring is directly monitored, any reduction in spring flow should be more noticeable. Since the wetlands have water storage capacity and are seasonally recharged by precipitation and surface flows, the amount of impact would depend on the amount of surface recharge and the actual wetland water loss due to infiltration. Therefore, impacts could be seasonal and limited.

The southern (#2) wetland is habitat for the many-headed sedge (Carex sychnocephala), a State sensitive species, as indicated in the FEISS, with about 50 to 70 plants present. There are only about 4 known sites of the Carex sychnocephala in Washington so the plant is considered to be relatively rare. Normal seasonal water level fluctuations are a situation to which this plant is adapted and year to year fluctuations are probably tolerated if not too extreme, but extended alteration of the wetland conditions would likely result in the loss of the population. As noted in the 1991 botanical survey, "Peripheral populations of plants with a wider distribution are regarded as deserving special attention due to their importance in the genetic diversity of the species. Such populations are adapted to climatic conditions at the extremes of the species' tolerance ..." "Wetland species such as this one are adapted to specific moisture regimes, and substantial change in water supply might go beyond the tolerance of the species."

If required, the southern wetland can be recharged by pumping water from an on-site source (e.g., Core Shed well) directly into the wetland. This would mitigate any substantive water loss from groundwater drawdown and would maintain the habitat until the water levels are restored by mine refilling. The 11/30/94 ROD, Section IV.M.22, includes a mitigation measure for supplementing the water recharge to these wetland if necessary, so no unmitigated impacts are predicted.

Seasonal impacts to vegetation resulting from low recharge would be reflected by the reduced abundance of hydrophytic plant species (e.g., juncus, carex, eleocharis) and the increased abundance of more xeric or upland species (e.g., bromus, poa, festuca). Since the hydric soils which comprise the restricting layer and shoreline of these wetlands will not be disturbed, a seed bank of hydrophytic plant species will be available to recolonize these sites when surface recharge increases.

The northern wetland can not be artificially recharged readily and could potentially be influenced artificial drawdown associated with the mining operation. This could result in a loss of surface water and a reduction in wetland function on a seasonal basis. On a regional basis, the loss of about 0.5 acres of wetland habitat for several months a year is not significant. On a site specific basis, macroinvertebrates, amphibians and some bird species may occur in reduced numbers or be temporarily displaced.

Therefore, no significant unmitigated impacts to these sites are anticipated.

6.11.2 Alternative 1 - No Action

Mitigated impacts would involve the same intensity and effect as those analyzed in the FEISS (Sections 4.0 and 5.0) for the southern wetlands. Due to the limited northern extent of mine workings, no impacts were predicted to the northern wetlands.

6.11.3 Alternative 2 - Enlarged Interim Expansion

Mitigated impacts would involve essentially the same impacts as those described in Section 6.12.1, with the same intensity and effect as the impacts analyzed in the FEISS (Sections 4.0 and 5.0). No significant unmitigated impacts to wetlands are predicted although it is possible that there might be some limited short-term effects.

6.12 WILDLIFE

6.12.1 Proposed Action

Impacts to wildlife are as described in the FEISS, Sections 4.0 and 5.0. The biological evaluation[13] has determined that the Lamefoot Mine is not likely to further the need to list the Canada lynx as threatened or endangered under the Endangered Species Act. Habitat and base prey are not present for the Canada lynx at the project area. There would be no impact to bull trout since neither fish nor habitat are present.

It is not likely that a goshawk would occupy the project area while the mining operation is active. Habitat is present but is not occupied. It is possible, but not probable, that a goshawk may nest within the project area or that part of the project area could be incorporated in a territory once the mine is no longer operational.

6.12.2 Alternative 1 - No Action

Mitigated impacts would be involve the same intensity and effect as those analyzed in Section 6.12.1 and in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA.

6.12.3 Alternative 2 - Enlarged Interim Expansion

Mitigated impacts would involve the same intensity and effect as those analyzed in Section 6.12.1 and in the FEISS (Sections 4.0 and 5.0), as modified by the 9/20/95 EA.

6.13 RECOMMENDED MITIGATION MEASURES

Provisions for expanding the monitoring network are already required and authorized under the 11/30/94 ROD, as needed, for the life of the program (up to 30+ years after closure). All of the water resource monitoring and reporting measures proposed will be required to be installed under Alternative 1 except for proposed LF-17 which is specific to expansions for the Proposed Action and Alternative 2. All monitoring revisions would be required under the Proposed Action and Alternative 2.

The other mitigation measures described are also already required under the 11/30/94 ROD, as modified by the 9/20/95 ROD, for all operations in all existing authorized areas. These measures would be among those applied to expansion areas under the Proposed Action and Alternative 1 and are reiterated here for emphasis due to there particular relevance to the issues described in this EA.

6.13.1 Proposed Action

1. Install new monitoring stations as noted below and illustrated in **Figure 20**. Add these stations to the interpretive program for determination of background water quality and long term monitoring using the same format and parameters as existing stations. Specific locations, depths, depth and other parameters to be determined based on field review and consultation with BLM.

SP-2: Surface water monitoring station using the same procedures and parameters as those used for Wolf Camp Spring. Provides a potential pathway identifier and point for detection of water quality impacts at an existing downgradient seep site. Location illustrated in Figure 9. Specific location shown on Hydro-Geo Appendix A, Figure 1(29). Monitor as in item #5 at start.

SP-3 Surface water monitoring station using the same procedures and parameters as those used for Wolf Camp Spring. Provides a potential pathway identifier and point for detection of water quality impacts at an existing downgradient seep site. Location illustrated in Figure 9. Specific location shown on Hydro-Geo Appendix A, Figure 1(29). Monitor as in item #5 at start.

LF-15: Deep water quality monitoring well as identified by Hydro-Geo(26) on the east side of Curlew Lake Fault. Purpose: to help determine groundwater flowpaths and whether the Curlew Lake Fault is a barrier to groundwater flow, and to detect any water quality impacts from outflow via groundwater. Tie measurements to LF-17 to give the head comparison across the fault. Monitor as in item #2.

LF-16: Piezometer as identified by Hydro-Geo(26) on the west side of Curlew Lake Fault. Purpose: to help determine groundwater flowpaths and whether the Curlew Lake Fault is a barrier to groundwater flow. Tie measurements to LF-16 to give head comparison across fault. Depth to be determined. Monitor as in item #2.

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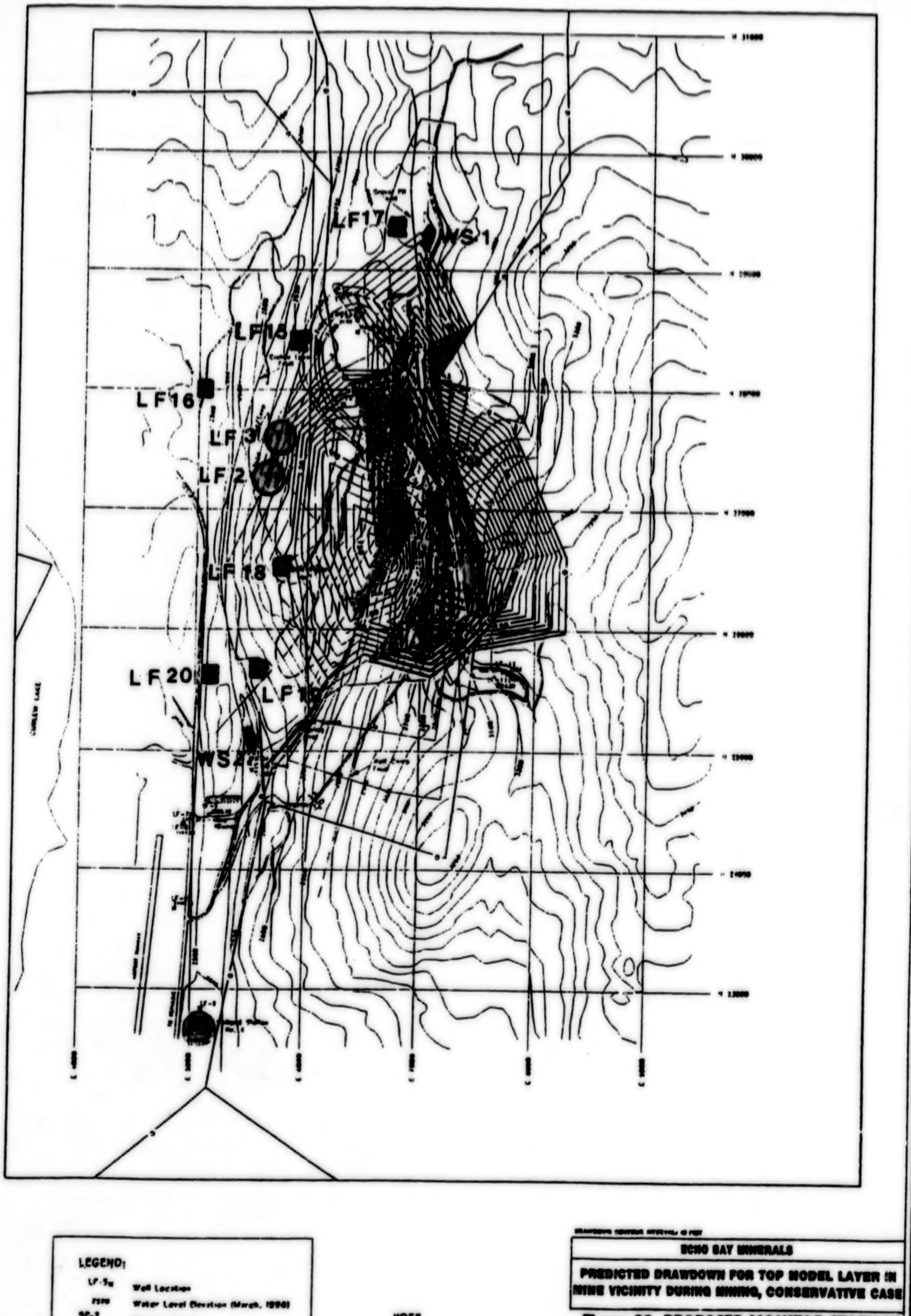

Figure 20. PROPOSED MONITOR STATIONS. Wells/piezometers/springs - locations are approximate, may require relocation due to slopes and accessibility. Existing wetlands station - add water quality.

LF-17: Piezometer on topographic bench northwest of Wetland #1 and west of surface trace of Gravel Pit Fault. Purpose: to monitor water level changes that may occur in the north area. Projected depth about 400 ft. extending about 100 ft. below the fault contact. Location as shown in Appendix C.

LF-18: Deep water quality monitoring well. Approximate location shown in Appendix C. Located west of LF-4. Purpose: to fill a gap in the monitoring program and help determine groundwater flowpaths and gradients related to existing sulfate zonation and to detect any water quality impacts from outflow. Projected depth to be determined (estimate 500-600 ft.). Monitor as in item #2.

LF-19: Shallow water quality monitoring well (estimate 200-300 ft.). Located between 25000N and 26000N on the east side of Curlew Lake Fault in approximate location shown in Appendix C. Purpose: to measure groundwater levels to determine flowpaths and determine whether the Curlew Lake Fault is a barrier to groundwater flow, and to detect any water quality impacts from outflow. Tie measurements to LF-20 to give the head comparison across the fault. Monitor as in item #2.

LF-20: Piezometer located between 25000N and 26000N on the west side of Curlew Lake Fault in approximate location shown in **Figure 20**. Purpose: to measure groundwater levels to help determine flowpaths and determine whether the Curlew Lake Fault is a barrier to groundwater flow, and to detect any water quality impacts from outflow. Depth to be determined (estimate 200-300 ft.). Complete well to same elevation as LF-6. Tie measurements to LF-19 to give the head comparison across the fault. Monitor as in item #2.

Wetland #1: Expand existing data collection to include water quality sampling for full water quality parameter suite (long list) as in item #5. Needed to determine background water quality and establish this as a wetland background (upgradient) monitoring station for comparison against possible future water quality impacts at wetland #2 and 3.

Wetland #2: Expand existing data collection to include water quality sampling for full water quality parameter suite (long list) as in item #5. Needed to determine background water quality for comparison against possible future water quality impacts at wetland #2 and 3.

Wetland #4: Expand existing data collection to include water quality sampling for full water quality parameter suite (long list) as in item #5. Needed to determine cause of upward trend in conductivity and background water quality for comparison against possible future water quality impacts at wetlands 1, 2, and 3.

2. Perform monitoring at the new wells and piezometers on a monthly basis for the long list of water quality parameters for at least twelve consecutive months from the date of first sampling before making an initial determination of baseline water quality and establishing baseline levels to be used in conjunction with trigger limits for corrective actions. After the initial monthly sampling period, a determination would need to be made on whether intervals could be increased to quarterly sampling.

3. Revise the Hydrologic Monitoring Plan in the Plan of Operations to include existing wells LF-13 & 14, three additional monitoring wells for water level and water quality monitoring, three piezometer installations for water levels, two spring monitoring stations for water quality, and expanded water quality monitoring (long list) at wetlands #1, #2 and #4.

4. Monitor for both total and dissolved metals for all constituents required by the State of Washington groundwater criteria until data collection has been completed for background determination.

5. Each wetland and spring station would be monitored monthly for collection of least 6 monthly samples (not counting winter months

when the wetlands are dry or frozen) and as long as needed using the long list of parameters. After at least 6 samples are collected, the data would analyzed to determine if longer sampling intervals may be adequate.

6. All new stations would be added to the monitoring network (including LF-13 & 14). Data would be collected, recorded and reported on both paper format and on computer disk (spreadsheet/database) to the BLM as part of the overall monitoring program. Data from the water quality monitor wells, piezometers, and wetland stations would be analyzed as part of the quarterly, annual and longer-term reports submitted to BLM. Data would include records of water discharge quantities from the mine portal, regardless of the disposal location, and the water quality test results for that water.

7. Prepare plan view maps and sections to show the "as-built" boundaries of mining zones as they are developed, and submit those illustrations with monthly monitoring reports. Provide full monitoring data on all activities in accordance with the measures in the plan of operations. Report all backfill monitoring data on both paper format and on computer disk (spreadsheet/database) on a monthly basis.

8. Complete verification inspections of grouting of all past surface and underground boreholes and provide updated reports to BLM.

9. Continue requirements to initiate source control, treatment or other control measures in accordance with the plan of operations and the 11/30/94 ROD as modified by the 9/20/95 ROD, if monitor wells show persistent detections of elevated levels of nitrates or other dissolved constituents outside the project area.

The modifications proposed in the alternative and the measures required by the Final Lamefoot ROD of 11/30/94, as modified by the 9/20/95 ROD and incorporated into the plan of operations, would likely insure the prevention of most possibilities for unnecessary or undue degradation, although there are some uncertainties in predictive capabilities. Examples of these measures include adequate closure designs for mine openings, grouting seeps, fractures and surface and underground boreholes during operations, grouting post-closure surface seeps that develop, characterization of background water quality and establishment of trigger limits to initiate corrective actions, long term monitoring, and potential water treatment if other corrective measures are found to be inadequate.

If the recommended mitigation measures are also incorporated into the proposed action, any uncertainties in predictive capabilities can be overcome and it would be unlikely that the proposed operations would result in unnecessary or undue degradation outside the project area.

6.13.2 Alternative 1 - No Action

Same recommendations as Section 6.13.1, except without the piezometer installation northwest of the northern wetland.

6.13.3 Alternative 2 - Enlarged Interim Expansion

Same recommendations as Section 6.13.1.

6.14 OTHER ENVIRONMENTAL CONSEQUENCES

The FEISS (Section 5.0) addressed "Unavoidable Adverse Impacts; Short-Term Uses versus Long-term Productivity; and Irreversible and Irretrievable Commitments of Resources." Mitigated impacts for the Proposed Action and all alternatives would have the same intensity and effect as those described in the FEISS. This EA did not reveal any significant unmitigated impacts that would exceed or contradict the FEISS analysis.

7.0 AGENCIES AND ORGANIZATIONS CONSULTED

Bureau of Land Management
-Spokane District Office, Spokane, WA
-OR/WA State Office, Portland, OR
-NV State Office, Reno, NV
-National Applied Resources Science Center,

Denver, CO
Environmental Protection Agency
-Region 10, Seattle, WA
-Headquarters, Washington, D.C.
U.S. National Resource and Conservation Service
-Spokane, WA
Washington State Department of Ecology
-Spokane, WA
Washington State Parks and Recreation Commission
-Curlew Lake, WA
Ferry County Commissioners
-Republic, WA
Ferry County Planning & Building Department
-Republic, WA
Mayor, City of Republic
-Republic, WA
Hydro-Geo Consultants, Inc.
-Lakewood, CO
Adrian Brown Consultants, Inc./Innovative Environmental Solutions
-Denver, CO
Schafer & Associates, Inc.
-Bozeman, MT
Echo Bay Minerals Company
-Republic, WA
-Englewood, CO

8.0 KEY SUPPORTING DOCUMENTS

1. Final Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion. Prepared by: Woodward-Clyde Consultants, Inc., Denver, Colorado. Prepared for: Spokane District BLM. October 1994

Comprehensive analysis of the Proposed and Selected Alternatives and impacts of mining to the 2200 foot msl elevation.

2. Record of Decision - Lamefoot Mine Environmental Impact Statement Supplement to the Kettle River Key Project Expansion. Prepared by: Spokane District, BLM. Prepared for: Echo Bay Minerals Company, Republic, Washington. November 30, 1994

Comprehensive summary of the Selected Alternative and the mitigation measures to be incorporated into the Plan of Operations. Mining not allowed below the 2750 ft. elevation.

3. Lamefoot Mine Environmental Assessment - Full Mining Proposal; Finding of No Significant Impact. Prepared by: Spokane District, BLM. Prepared for: Echo Bay Minerals Company. September 20, 1995.

Evaluates impacts of mining from the 2750 ft. elevation to the 2200 ft. elevation, based on the results of technical studies required by the 11/30/94 ROD.

4. Record of Decision, Approval of Expansion of Development and Mining Phases below the 2750 Foot MSL Elevation. Prepared by: Spokane District, BLM. Prepared for Echo Bay Minerals Company. September 20, 1995

Authorized expansion of mining from the 2750 ft. elevation to the 2200 ft. elevation and summarized additional mitigation measures to be incorporated into the Plan of Operations. Revised backfill method and eliminated adit construction and relocation of Wolf Camp road.

5. Record of Decision, Approval of Mining Plan of Operations, In Part, Mining Between 2200 Ft. and 3070 Ft. Elevation MSL. Prepared by: Spokane District, BLM. Prepared for: Echo Bay Minerals Company. December 12, 1996

Approves Plan of Operations revisions, subject to the requirement that the plan conform to and document the measures required by the 11/30/94 and 9/20/95 RODs. Defines requirements for achieving ROD criteria on every 5000 ton sample lots. Specifies mining above 3070 ft. not authorized until completion of technical analysis of potential impacts

6. Lamefoot Plan of Operations - August 1996 Modification. Prepared by: Echo Bay

Minerals Company, Republic, Washington, January through November 1996. Prepared for: Spokane District BLM; approved December 12, 1996.

Detailed description of operating procedures for mining, monitoring and reclamation. Includes Hydrologic Monitoring Plan, sampling plan, and recordkeeping procedures.

7. Decision - Lamefoot Mine Plan of Operations Notice of Noncompliance. Prepared by: Spokane District, BLM. Prepared for: Echo Bay Minerals Company. March 4, 1997.

Required full implementation of measures in RODs to correct deficiencies in backfill placement, proportions, and quantities of potentially acid generating rock (PAG). Required revision of models to evaluate the new life-of-mine estimates for PAG rock.

8. Decision - Lamefoot Mine Plan of Operations. Conditional Approval of the 3145 Access Ramp for Exploration Drilling. Prepared by: Spokane District, BLM. Prepared for: Echo Bay Minerals Company. June 20, 1997.

Authorizes exploration drift and drilling to identify potential characteristics of the 3070 proposed mine expansion area at the south end of the mine. Amount of cemented backfill increased to meet proportions in previous ROD criteria.

9. Decision - Lamefoot Mine Plan of Operations. Conditional Approval of Development of the 2225N Exploration Drift for Exploration Drilling. Prepared by: Spokane District, BLM. Prepared for: Echo Bay Minerals Company. June 27, 1997.

Authorizes exploration drift and drilling to identify potential characteristics of the North Lamefoot proposed mine expansion area north of 27500N. Amount of cemented backfill increased to meet proportions in previous ROD criteria.

10. Decision - Lamefoot Mine Plan of Operations. Conditional Approval of Extension of Zone 4 Drifts on Three Levels (2420, 2485, 2550) to Points North of 27,500N for Access. Prepared by: Spokane District, BLM. Prepared for: Echo Bay Minerals Company. October 20, 1997.

Authorizes extension of mine access workings subject to potential additional mitigation requirements. Amount of cemented backfill increased to meet proportions in previous ROD criteria.

11. Letter - Interim Modification, Maps and Sections. Prepared by: Spokane District, BLM. Prepared for Echo Bay Minerals Company. March 30, 1998.

Acknowledges receipt; lists the maps and sections illustrating the interim expansion.

12. Letters Documenting Telephone Conversation: Prepared by: Spokane District, BLM. Prepared for: Washington Department of Ecology (WADOE). April 6, 1998; WADOE response letter. April 9, 1998.

WADOE has review authority under SEPA and referenced possibility of Ferry County requirements under Ferry County Critical Area Ordinance. Confirms that BLM EA addressing potential habitat changes is adequate for WADOE review needs. Neither WADOE nor Corps of Engineers require permits or wetland delineation if groundwater drawdown from underground mining has potential to impact wetlands.

13. Biological Evaluation FWS Reference #:1-3-94-I-136 (Lamefoot Mine Consultation). Prepared by: Spokane District, BLM. Prepared for: Fish and Wildlife Service. May 19, 1998.

Updates original FEISS biological evaluation under Endangered Species Act under informal consultation process for Canada lynx and bull trout (species *proposed for listing) and northern goshawk (species of concern under status review).*

14. Letter Documenting Telephone Conversation. Prepared by: Spokane District, BLM. Prepared for: Ferry County Planning Department. May 26, 1998.

Confirmation that BLM EA addressing potential habitat changes is adequate for County review needs, and that Ferry County would not have permitting requirements if groundwater drawdown from underground mining has potential for impacts to wetlands (e.g., under Ferry County Critical Area Ordinance).

15. Request for Mining in Upper Zone 2, Mining in Zone 4, Primary Development in Zone 6 and Minor Ramp Construction in Zone 7. Prepared by: Echo Bay Minerals Company. Prepared for: Spokane District, BLM. February 4, 1998.

Proposed plan modification for "Interim" expansion at the north and south ends of the mine.

16. Review of the Impact of Mining on Shallow Rock Mass at the Lamefoot Mine, Phase I: Tasks I & II, Sources and Extent of Existing Geomechanical Information Pertaining to Previous Lamefoot Mine Extraction Impact and Surface Subsidence Analyses. Prepared by: Mining Laboratories, CANMET. Prepared for: Spokane District, BLM. February 27, 1997.

Evaluates previous studies, identifies extent and use of available information, and supplementary data required for the mine evaluation.

17. Review of the Impact of Mining on the Shallow Rock Mass at the Lamefoot Mine, Washington State, Phase I: Preliminary Assessment of Site Conditions and Recommendations for Future Work. Prepared by: Mining Laboratories, CANMET. Prepared for: Spokane District, BLM.

Reviews previous subsidence studies. Evaluates site conditions and identifies data needed for numerical modelling.

18. Review of the Impact of Mining On the Shallow Rock Mass at the Lamefoot Min, Washington State, Phase II: Numerical Modelling and Analysis of Rock Mass Displacements and Subsidence. Prepared by: Canada Centre for Mineral and Energy Technology. Prepared for: Spokane District, BLM. July 1997 (as supplemented by letter to BLM, September 4, 1997).

Final report of the analysis of the effects of subsidence and rock mass displacement of the crown pillar. Identifies that the void space in fractures in the crown pillar will increase during and after mining, possibly creating pathways for water movement through the crown pillar.

19. Response to Comments on CANMET Subsidence Analysis. Prepared by: Canada Centre for Mineral and Energy Technology. Prepared for: Spokane District, BLM. January 23, 1998.

Provides responses to comments from Echo Bay Minerals Company consultants on impacts of mining and proposed monitoring methods.

20. Effect On Inflow of Crown Pillar Permeability. Prepared by Adrian Brown Consultants, Inc. Prepared for: Echo Bay Minerals Company. April 14, 1997.

Describes inflow to the mine and saturation of the crown pillar as considered in the 1995 technical studies.

21. Crown Pillar Permeability, Lamefoot Mine. Prepared by: Adrian Brown Consultants, Inc. Prepared for: Echo Bay Minerals Company. January 19, 1998.

Comments on CANMET study and effect on permeability of the crown pillar.

22. North Lamefoot Hydrogeologic Study, Echo Bay Minerals - Kettle River Operations, Lamefoot Mine, Republic, Washington. Prepared by: Hydro-Geo Consultants. Prepared for: Echo Bay Minerals Company. January 10, 1997.

> *Report on installation and testing of two new monitor wells installed at the north end of the proposed mine expansion.*

23. Lamefoot Groundwater Flow/Chemical Fate Evaluations. Prepared by: Adrian Brown Consultants, Inc. Prepared for: Echo Bay Minerals Company. April 28, 1997.

> *Discusses proposed approach to re-evaluation of groundwater flow and chemical fate conditions.*

24. Lamefoot Groundwater Flow Evaluation. Prepared by: Adrian Brown Consultants, Inc. Prepared for: Echo Bay Minerals Company. May 14, 1997.

> *Describes infiltration rate and hydraulic conductivity input parameters proposed for use in the hydrology model.*

25. Response to EPA and BLM Comments on Lamefoot Hydrology. Prepared by: Adrian Brown Consultants, Inc. Prepared for: Echo Bay Minerals Company. August 28, 1997.

> *Responds to questions on hydraulic conductivity, discussion of recharge, flows and water balance, calibration of the model, sensitivity analysis, geology.*

26. Addendum to the North Lamefoot Hydrogeologic Study, Echo Bay Minerals Kettle River Operations, Lamefoot Mine, Republic, Washington. Prepared by: Hydro-Geo Consultants, Inc. Prepared for: Echo Bay Minerals Company. November, 1997.

> *Describes discharge tests on fractured zones encountered by exploratory drilling along the 2225N exploration drift. Includes potentiometric map identifying the approximate pre-mining potentiometric surface for groundwater.*

27. Response to Comments by BLM on Lamefoot Incremental Expansion. Prepared by: Adrian Brown Consultants, Inc. Prepared for: Echo Bay Minerals Company. April 23, 1998.

> *Responds to numerous comments from BLM and EPA on a draft version of the Impact Evaluation report.*

28. Lamefoot Project Incremental Expansion Hydrologic Impact Evaluation. Prepared by: Adrian Brown Consultants. Prepared for: Echo Bay Minerals Company. May 20, 1998 (with revised plates, June 23, 1998).

> *Replaces Hydrology discussion in May 1998 Impact Evaluation. Responds to comments from BLM, and includes expanded discussion of how infiltration was determined.*

29. Impact Evaluation for the Proposed Interim Expansion for the Lamefoot Mine (excluding sections and appendices on hydrology modeling). Prepared by: Schafer & Associates, Adrian Brown Consultants, and Hydro-Geo Consultants. Prepared for: Echo Bay Minerals Company, Republic, Washington. May, 1998 (revised June 1998)

> *Detailed summary of current data on hydrogeology and results of geochemistry and hydrology modeling. Presents model results from input parameters identified by BLM (Conservative Case) for Reasonably Foreseeable Impact determination. Also includes results based on parameters identified by the consultants (Expected Case) to identify a scenario with lesser impacts they consider to be more probable.*

30. Letter - Timing Issues for the Echo Bay Lamefoot Mine. Prepared by: Echo Bay Minerals Company, Republic, Washington. Prepared for: Spokane District, BLM. July 16, 1998.

Provides estimated timeframes for the during of operations under the a) existing authorizations, b) the proposed interim expansion into North Lamefoot and the 3070+ portion of Zone 2, and c) the possible future "full" expansion that would include all of the 3070+ expansion in Zone 2 and the entire expansion into North Lamefoot, including Zone 7 and "north" North Lamefoot.

31. Order No. DE 98WQ-E382. Prepared by Washington Department of Ecology. Prepared for: Echo Bay Minerals Company. May 27, 1998.

Required investigation of the source of elevated levels of nitrate in groundwater, preparation of a report, and temporary adjustment to water discharge procedures.

32. Lamefoot Mine - Addendum to the 1997 Cumulative Trend Analysis Report of Water Quality Data. Prepared by: EnviroData Solutions, Inc. Prepared for: Echo Bay Minerals Company. June 12, 1998

Annual review of data on water quality and water levels.

33. Lamefoot Mine - 1997 Cumulative Trend Analysis Report of Water Quality Data. Prepared by: EnviroData Solutions, Inc. Prepared for: Echo Bay Minerals Company. April 29, 1997(8).

Annual review of data on water quality and water levels.

34. Lamefoot Mine - 1996 Cumulative Trend Analysis Report of Water Quality Data. Prepared by H_2O Data, Inc. Prepared for: Echo Bay Minerals Company. April 29, 1997.

Annual review of data on water quality and water levels.

35. Lamefoot Mine - 1995 Cumulative Trend Analysis Report of Water Quality Data. Prepared by H_20 Data, Inc. Prepared for: Echo Bay Minerals Company. April 28, 1996.

Annual review of data on water quality and water levels.

36. Use of Encapsulated Waste Rock for Cemented Backfill. Prepared by: Schafer & Associates, Bozeman, Montana. Prepared for: Echo Bay Minerals Company, Republic, Washington. April 13, 1995.

Technical analysis of composition of existing waste rock dump and its use as cemented backfill.

37. 2750 Level Hydrology and Hydrogeochemistry Final Report. Prepared by: Adrian Brown Consultants, Inc.; Hydro-Geo Consultants, Inc.; Schafer & Associates, Inc. Prepared for: Echo Bay Minerals Company, Republic, Washington. June 1995.

Detailed technical report summarizing the result of groundwater and geochemical investigations. Includes Appendix A - Hydrogeologic Summary, and Appendix B - Background Groundwater Quality Analysis. Appendix A includes descriptions of surface monitoring wells, underground test holes, drill logs, test procedures and results, and the groundwater tests conducted. Appendix B includes the sampling data from monitor wells, a statistical analysis of the data, and an interpretive report.

38. 2750 Level Hydrology and Hydrogeochemistry Final Report: Appendix C - Geochemical Characterization for the Lamefoot Project. Prepared by: Adrian Brown Consultants, Inc.; Hydro-Geo Consultants, Inc.; Schafer & Associates, Inc. Prepared for: Echo Bay Minerals Company, Republic, Washington. June 1995.

Detailed technical report describing laboratory and field tests conducted for site characterization. Includes raw data from tests and results of modelling.

39. Replacement Pages for Appendix C8, Scanning Electron Microscope Results, of Appendix C - Geochemical Characterization for the Lamefoot Project. Prepared by: Schafer & Associates, Inc., Bozeman, Montana. Prepared for: Spokane District BLM. June 14, 1995.

Reproductions of photos and colored graphs for better clarity.

40. Changes to 2750 Level Report: Appendix C4, C8. Prepared by: Adrian Brown Consultants, Inc., Denver, Colorado. Prepared for: Spokane District BLM. June 26, 1995.

Additional laboratory data sheets showing test results.

41. Impact Evaluation For Full Development of the Lamefoot Mine. Report 1371A/950714. Prepared by: Adrian Brown Consultants, Inc.; Hydro-Geo Consultants, Inc.; Schafer & Associates, Inc. Prepared for: Echo Bay Minerals Company, Republic, Washington. July 1995.

Detailed technical report on attenuation and neutralization tests, and modeling of mine refilling, mine refill water quality, and analyses of transport and attenuation. Includes a comprehensive summary integrating the results and conclusions of the earlier 2750 report (Appendix A-C) with the Impact analysis volume.

42. Changes to 2750 Level Hydrology and Hydrogeochemistry Final Report. Prepared by: Adrian Brown Consultants, Inc., Denver, Colorado. Prepared for: Spokane District BLM. July 14, 1995.

Provides additional data and descriptions in response to BLM questions resulting from a technical completeness review.

43. An Evaluation of Potential Replacement Backfill Sources for the Lamefoot Mine. Submitted by: Schafer & Associates, Bozeman, Montana. Submitted to: Echo Bay Minerals Company, Republic, Washington. July 20, 1995.

Detailed technical report summarizing the geochemical characterization of the Corl and Torboy gravel deposits in comparison to the Wolf Camp Quarry. Includes laboratory test data and interpretations.

44. Proposed Mining Expansion Project at the Corl Site: Wetland Delineation Technical Baseline Report. Prepared by: Woodward-Clyde Consultants, Portland, Oregon. Prepared for: Echo Bay Minerals Company, Republic, Washington. August 1995.

Inventory for wetlands at the proposed Corl gravel pit and along the haul road route.

45. 2750 Review - Final Supplemental Plan of Operations. Prepared by: Schafer & Associates, Inc., Bozeman, Montana. Prepared for: Echo Bay Minerals Company, Republic, Washington. August 7, 1995.

Echo Bay request for changes in Plan of Operations under Selected Alternative.

46. Response to BLM 2750 Review of August 24, 1995. From: Echo Bay Minerals Company, Republic, Washington. To: Spokane District BLM. September 1, 1995.

Provides responses to BLM technical questions requesting clarification on analyses, interpretations and modeling approaches used in the 2750 Report.

47. Response to BLM Review, August 25, 1995, of Supplemental Plan of Operations. From: Echo Bay Minerals Company, Republic, Washington. To: Spokane District BLM. August 30, 1995.

Provides responses to BLM questions on quantities and uses proposed for materials

from the Corl and Torboy sites, total amount of waste rock production, total amount of backfill needed, public safety measures for Wolf Camp Road, and resource inventory reports for Corl pit and access road.

48. Evaluation of Proposed Changes in Backfill Plan, Lamefoot Mine, WA. Prepared by: Russell L. Levens, U.S. Bureau of Mines, Spokane, Washington. Prepared for: Spokane District BLM. August 31, 1995.

Technical report analyzing proposed backfill plan changes in light of new data and interpretations on groundwater and geochemistry, as presented in the 2750 Report and Impact Evaluation.

49. Environmental Impacts of Cemented Mine Waste Backfill, Prepared by: R.L. Levens, A.D. Marcy, and C.M.K. Boldt, 1996. U.S. Bureau of Mines Report of Investigations 9599.

Evaluates use of cemented backfill to change the chemical and physical characteristics of backfill, buffer acid-producing reactions, and reduce acid rock drainage by controlling sulfide oxidation.

50. Groundwater Technical Memorandum. Prepared by: Woodward-Clyde Consultants. Prepared for: Spokane District, BLM. 1994.

Describes technical background for various FEISS items, including monitoring wells, groundwater flow, dilution, travel times for mine drainage, water quality impacts, potential health effects for related to water quality for various constituents, mine inflow, water treatment, grouting, and impact assessment.

51. Manganese; Solids (Dissolved) and Salinity in EPA Quality Criteria for Water, 1986, EPA 440/5-86-001.

Describes effects of elevated levels of these constituents in water.

52. Drinking Water: National Primary Drinking Water Regulations -- Sulfate; National Primary Drinking Water Implementation; Proposed Rule. Federal Register, Vol. 59, No. 243, December 20, 1994.

Describes potential adverse health effects for infants, travelers, and new residents in areas that have high sulfate levels in their drinking water. Contains alternatives that allow public water systems the flexibility to select compliance options appropriate to protect the population served.

53. Pyrite Oxidation Under Unsaturated Conditions, Part I: Abiotic Oxidation, 1987, R.W. Hammack in Proceedings - 1987 National Meeting American Society for Surface Mining and Reclamation, Fourth Biennial Symposium on Surface Mining and Reclamation on the Great Plains.

Describes effects of humidity in increasing pyrite oxidation.

54. Botanical Survey for Echo Bay Exploration, Republic, Washington. Prepared by: Mastrogiuseppe Environmental Consultants. Prepared for: Echo Bay Exploration Co. 1991.

Botanical survey of the project area; describes Carex sychnopcephala and habitat.

55. The Use of Wetlands for Improving Water Quality to Meet Established Standards. B.A. Filas, T.R. Wildeman. Presented at the Nevada Mining Association Annual Reclamation Conference., Sparks, Nevada, May 1992.

Describes removal of sulfate and manganese by wetlands.

56. Assessment of Acid Mine Drainage Remediation Schemes On Ground Water Flow Regimes At A Reclaimed Mine Site, 1994, M.A. Gabr, J.J. Bowders, and M.S. Runner in Proceedings of the International Land Reclamation and Mine Drainage Conference

and Third International Conference on the Abatement of Acidic Drainage.

Describes effectiveness of a grout wall in reducing recharge and flow through a mine.

57. Mine Seepage Problems In Drift Mine Operations, 1996, C. DeRossett, D.E. Johnson, and D.B. Bradshaw in Proceedings of the Thirteenth Annual Meeting, American Society for Surface Mining and Reclamation.

Case studies of effects of hydrostatic pressure. changes to groundwater and potential for creating seepage areas where mine pools and drill holes intersect with the joint system.

58. Comparisons of Acid Mine Drainage Predictions With Historical Records, 1996, K.A. Morin and N.M. Hutt in Proceedings of the Third Australian Acid Mine Drainage Workshop.

Case studies evaluating reasons for inaccurate predictions.

59. An Overview of Acid Mine Drainage Control and Treatment Options, Including Recent Advances, 1996, J.R. Taylor, C.L. Waring, N.C. Murphy and M.J. Leake in Proceedings of the Third Australian Acid Mine Drainage Workshop.

Identifies numerous methods to control and treat acid mine drainage.

APPENDIX A

COMPARISON OF PREDICTIONS

1994-1995-1998

APPENDIX A. SUMMARY OF CONCLUSIONS FROM STUDIES/EAs IN 1995 AND 1998 IN COMPARISON WITH FEISS CONCLUSIONS ABOUT IMPACTS.

CONCLUSIONS FROM 1994 FEISS	CONCLUSIONS FROM 2750 REPORT AND 1995 EA	CONCLUSIONS FROM 1998 IMPACT STUDIES AND 1998 EA
Surface subsidence less than 1.8 inches, no substantial increase in flow through crown pillar in or out of mine. Grouting required to prevent outflow through boreholes and minimize outflow through fractures capable of carrying 1 gpm or greater.	Surface subsidence less than 1.1 inches, no increase in flow through crown pillar in or out of mine. Grouting required to prevent outflow through boreholes and minimize outflow through fractures capable of carrying 1 gpm or greater.	Surface subsidence less than 1 inch, rock mass displacement within the crown pillar increases void space of fractures by up to 0.8 inch, potentially allows all inflow water to exit through crown pillar fractures. Grouting same as FEISS, but all boreholes and fractures may not have been grouted as planned; potentially leaves pathways from the mine workings to the surface.
Mine refills to level of Wolf Camp valley; about 2750 ft. elevation	Mine refills completely to approximate pre-mining levels (about 2950 ft. elevation; within about 30 ft. of surface).	Mine partially refills to at least the level of Wolf Camp valley (2750 ft. elev.) or higher, depending on extent of outflow through crown pillar and faults/fractures.
Mine inflows at 11 gpm to 124 gpm during operations and refilling.	Mine inflows at 10 gpm during operations and refilling.	Mine inflows of up to 46 to 115 gpm during operations and refilling, slows to 13 to 26 gpm after partial refilling to valley.
About 4.7 years to partially refill to about the 2750 ft. elevation.	About 50 years to refill completely to about the 2950 ft. elevation.	About 5-28 years to partially refill; equilibrium level at about Wolf Camp valley (2750+ ft. elev.), depending on maximum inflow and outflow rate and maximum refilling level. About 20-75 years to completely refill if the mine will retain water above valley level.
Mine flow-through (inflow and outflow) is about 11 gpm after refilling.	Mine flow-through (inflow and outflow) is about 5 gpm refilling, mainly through the rock mass.	Mine flow-through (inflow and outflow) is about 13-26 gpm after refilling, mainly through the crown pillar or faults.
Flow pathway to the west through rock into Wolf Camp valley and south along alluvium.	Flow pathway is generally to the west through the rock mass with no preferential pathways.	Either of previous two pathways possible. Pathway west through faults or crown pillar fractures into Wolf Camp valley, then south and west through alluvium; or pathway generally westward through bedrock down regional gradient with local control by faults/fractures.
Potential greater flows possible in fractures with capacity of up to 0.09 ft/day (10^{-5} cm/s).	Overall hydraulic conductivity is lower, about 1 ft/yr. (1×10^{-6} cm/s), and high fracture flow capacity is unlikely. Typical local fractures up to 50 ft./yr (5×10^{-5} cm/s); some limited fractures with hydraulic conductivity up to 10^{-4} cm/s.	Low hydraulic conductivity at southern and higher elevation mine workings as in 1995. Northern area in valley and to west has 10-100 times greater hydraulic conductivity. Fractures have hydraulic conductivity of 10^{-4} cm/s and a 5 ft. wide fracture zone at Wolf Camp fault has hydraulic conductivity of 10^{-3} cm/s.

APPENDIX A. SUMMARY OF CONCLUSIONS FROM STUDIES/EAs IN 1995 AND 1998 IN COMPARISON WITH FEISS CONCLUSIONS ABOUT IMPACTS.

CONCLUSIONS FROM 1994 FEISS	CONCLUSIONS FROM 2750 REPORT AND 1995 EA	CONCLUSIONS FROM 1998 IMPACT STUDIES AND 1998 EA
Water seeps into and out of the mine are controlled by mitigation measures in FEISS/POO; sulfate resistant grouting used for long term resistance to degradation.	Water seeps into and out of the mine controlled by same measures as in FEISS/POO.	Water seeps into and out of the mine controlled by same measures as in FEISS/POO. Northern limit of interim expansion evaluated. Future northern mining expansion excluded pending receipt of unfinished hydrological model and additional data on hydrology.
Unknown reactivity	Slow to moderately reactive.	Slow to moderately reactive.
Clastic and altered limestone are PAG. About 44% of wall rock (clastic) has higher ARD potential, up to 80% of wall rock is PAG.	Same as FEISS, but long lag time for ARD effects due to reactivity constraints, neutralization capacity in the backfill mitigation measures.	Same as FEISS, but long lag time due to reactivity constraints and neutralization capacity in the backfill mitigation measures.
About 1.5 million tons of PAG rock in crown pillar and wall rock. Crown pillar perpetually exposed.	About 1.5 million tons of PAG rock in crown pillar and wall rock. Crown pillar becomes saturated by refill.	About 1.5 million tons of PAG rock in crown pillar and wall rock. Crown pillar perpetually exposed.
About 1.6 million tons of backfill, including about 360,000 tons of waste rock. About 144,000 tons of PAG waste rock has ARD potential. Uses 345,000 tons cemented fill.	About 1.86 million tons of backfill, and less than 9% is PAG backfill (about 164,300 tons PAG waste rock) has ARD potential. Uses 250,000 tons cemented fill.	Up to about 2.0 million tons backfill, and up to 25% is PAG backfill (about 500,000 tons PAG waste rock) has ARD potential. May use up to 625,000 tons cemented fill.
Neutralized ARD. Concentrations in mine pool increase gradually over decades.	Localized ARD after long lag period; will not predominate on mine wide scale. Neutralized ARD predicted in mine pool and outflow. Concentrations in mine pool increase gradually over decades.	Localized ARD after long lag period; will not predominate on mine wide scale. Neutralized ARD in mine pool and outflow; and some water quality impacts possible from sulfate and manganese. Concentrations in mine pool increase gradually over decades.
Based on quarry backfill and bedrock attenuation, dilution	Based on Corl gravel backfill and bedrock attenuation, dilution	Based on test of existing backfill mixture (waste rock plus Corl gravel), tests of known supplemental backfill source, bedrock attenuation, dilution.
No nitrate impacts from surface discharge extend outside project area.	Elevated nitrate in monitor wells before changing explosives and ceasing use of infiltration pond.	Elevated nitrate levels continue outside project area at ore/waste pile and infiltration pond; source undetermined.
No nitrate impacts outside project area from underground use.	No nitrate impacts outside project area from underground use.	No nitrate impacts outside project area from underground use.
Low to medium concentrations of selected constituents in mine void: Fe, Mn, Zn, sulfate, nitrate, TDS	High levels of As, Se, Zn, Cu, Pb, Mo, Co, Cr, Ni will be released into water in the mine void.	Elevated antimony encountered at northern end of 2225N drift outside limits of expansion area. Elevated levels of As, Zn, Cu, Cd, Mn, sulfate will be released into water in mine void.

APPENDIX A. SUMMARY OF CONCLUSIONS FROM STUDIES/EAs IN 1995 AND 1998 IN COMPARISON WITH FEISS CONCLUSIONS ABOUT IMPACTS.

CONCLUSIONS FROM 1994 FEISS	CONCLUSIONS FROM 2750 REPORT AND 1995 EA	CONCLUSIONS FROM 1998 IMPACT STUDIES AND 1998 EA
Fe, Cd, Mn, Zn, Pb, As, Cu greatly attenuated. Mn, Zn more mobile. Sulfate, nitrate less attenuated; reduced by simple dilution and source extent chemical reactions.	Neutralization and attenuation will remove most metals post-closure, especially Cu & Zn; also will have elevated Fe, Mn, Zn, sulfate, nitrate, TDS. Will not remove all Se, As, sulfate or nitrate. Nitrate levels inside mine decline after mining ceases.	Neutralization and attenuation will remove most metals post-closure, especially Cu & Zn; remainder includes Fe, Mn, Zn, sulfate, nitrate, TDS; will not remove all Se, As, sulfate or nitrate. Sulfate & manganese may not be diluted to State standards and treatment may be needed.
Transit time about 240 years through 500 feet of bedrock and 3000 feet of alluvium.	Transit time about 40 years through 4000 feet of bedrock.	Initial 5-20+ years during refilling before water starts to migrate offsite. Then transit time potentially is years or less if direct discharge from boreholes, otherwise tens of years for movement along pathways 2350-4000 ft.
Dilution, attenuation, mixing 10:1 to 100:1 at Wolf Camp valley	Dispersion/dilution of 4,000:1 at Curlew Lake.	Dilution of 6:1 to 23+:1 in Wolf Camp valley. Dispersion/dilution of 4,000:1 at Curlew Lake.
ARD impacts exceed background and extend out of project limit within 30 years.	Negligible offsite ARD impacts and no impact to Curlew Lake. Inflow to mine for 50 years before outflow, then levels reduced to background during 40 years transit toward lake.	Low initial offsite ARD impacts. May exceed State water quality standards beyond project area boundary for Cd, Mn, sulfate and may impact private wells; no substantive impact to Curlew Lake. Concentrations still low at time of refilling and possible outflow but water quality declines over time and may require treatment to prevent impacts.
Drawdown limited to area surrounding mine workings (about 1500 ft. long).	Drawdown in limited to area surrounding mine workings (about 1500 ft. long).	Actual drawdown is limited to area surrounding mine workings; exploration drift to 28300 extends drawdown area. Drawdown extends about 700-1000 ft. wide, 3200 ft. long, 600+ ft. deep.
No workings or impacts projected to north of about 27500N.	No workings or impacts projected to north of about 27500N.	Mining proposed to 27850N. Drawdown projected 2800-3000 ft. wide, 4600-4900 ft. long, 350+ ft. during operations; 1800 ft. wide, 3800-4000 ft. long, 400 ft. deep after closure.
Possible reduction of flow to wetlands during mining. Water levels restored after refilling.	Effects to wetlands less likely than in FEISS; FEISS mitigation measures apply.	Effects to wetlands not predicted but possible seasonally; FEISS mitigation measures apply. Water levels restored after refilling.

APPENDIX B

DESCRIPTION OF PROPOSED ACTION

Thursday, March 26, 1998

Narrative Description of the Interim Mine Expansion Areas

This addendum request includes:

1] Mining the two lowermost lifts in the Zone 2 cut and fill area.
2] Mining Zone 4 Extension (Z4E)
3] Primary development in Zone 6 Extension (Z6E)
4] Ramp development for 1500 feet to access Zone 7

The following narrative describes the activities required to achieve the forgoing requests for mining and development. Note that this narrative and the accompanying drawings show the ore and development as we currently understand it. In mining areas, some small changes and modifications will necessarily occur as the ground is opened up and new data is added to our current store. For development in new areas such as 6E and 7, detailed 20 scale drawings are only used when essentially all data is in and has been included in the design work. Large scale plans and sections are more than adequate for our planning and decision making when accompanied by tonnage estimates as we have previously supplied the BLM. So in these areas, larger changes might be expected as work progresses and new exploration data is incorporated into the plan. Keep in mind that the larger scale maps and drawings previously supplied are for conceptual orientation and planning and not for detailed measurements and comparisons. For clarity, a plan view map of the entire mine is included as revised plate 2, with an Easting and a Northing coordinate line clearly labeled in red. A modified longitudinal drawing of the mine showing the proposed work is also included as revised drawing 12. Again, these views are conceptual, not for scaling. On 20 scale plan maps, new level development is shown in magenta, often overlapping existing workings in black, and ore boundaries are shown in red. A breakdown of rock types and tonnages described below is given in the table accompanying the original request.

1] In Zone 2, the lowermost cut and fill lifts with sill elevations at approximately 3085 and 3100 will be mined. The work will consist of driving a drift generally along the West ore contact and then slashing the East side to the footwall contact. Drawings 26 and 27 show the drifting and slashing . Lift 1 will be mined and then backfilled with unconsolidated material. After that, lift two will be mined and then similarly backfilled. For this Zone 2 mining, 45,000 tons will be removed and replaced with backfill material. Cross section drawings showing the proposed cut and fill levels were included with the original request.

2] In Zone 4E, work will consist of final development on 4 levels and longhole mining between the levels. The levels are : 2615, 2550, 2485, and 2420, illustrated in drawings 17, 18, 19, and 20 respectively. Note that drawing 20 shows Zone 4E development as well as Zone 6 work and possible Zone 6E development. The 2420 level is the transition horizon between 4E and 6E, i.e. the bottom of 4E and the top of 6E. These level developments consist of drifting and/or slashing to accommodate production drilling, blasting, and mucking. After development, the ore will be taken out between levels using longhole stoping methods. The ore and stope outlines are indicated on the cross section drawings 30 and 31 which are cut along Northing lines at 27,500 and 27,600 North, respectively. Total stope development and mining tonnage in Z4E totals 30,000 tons. Unconsolidated fill material will be placed in the stope voids following mining.

3] In Zone 6E, work will consist of primary (access) development on 5 levels. These levels are: 2420, 2355, 2290, 2225, and 2160 and are illustrated in drawings 20, 21, 22, 23, and 24, respectively. The development is drifting in waste with any ore encountered being only incidental to the access plan. Total drifting waste estimated is 41,241 tons. Ore outlines are shown in red, however these positions are tentative until all data has been evaluated. No mining is included in this request for Zone 6E. Cross section views of the proposed 6E developments are shown on drawings 30, 31, 32, and 33 which are cut along Northing lines at 27,500, 27,600, 27,700, and 27,800 North, respectively.

4] In Zone 7, about 1500 feet of ramping and access is planned. This ramp will be driven down from about the 2225 level at minus 12% to access the Zone 7 ore body with level access take offs at 2170, 2150, and 2100, included in the ramping request. A utility cutout is also planned part way down to facilitate the ramp work. A plan view of this Zone 7 ramp and facility development is illustrated in drawing 25. All ramping, cutouts, and level access take offs are planned in waste and total 42,912 tons. Cross sections views of the proposed Zone 7 ramping and associated development are shown on drawings 28, 29, 30, and 31 which are cut along Northing lines at 27,300, 27,400, 27,500, and 27,600 North, respectively.

END

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